Historical Analysis of Chemical Warfare in World War I for Understanding the Impact of Science and Technology

An Interactive Qualifying Project
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Abstract

Historians categorize eras of human civilization by the technologies those civilizations possessed, and so science and technology have always been hand in hand with progress and evolution. Our group investigated chemical weapon use in the First World War because we viewed the event as the inevitable result of technology outpacing contemporary understanding. Along with the main investigation, this IQP overviewed WPI's Great War related activities between 1914 and 1918. Further, this IQP includes an exhibition of World War I era artifacts, both to commemorate the centennial anniversary of the armistice and to gather data on modern interpretations of the conflict. We concluded that World War I is a prime example of the duality of science, and serves to warn against the misuse of technology.

Executive Summary

Historians categorize eras of human civilization by the technologies those civilizations possessed, and so science and technology have always been hand in hand with progress and evolution. The technology of the Bronze Age allowed humanity to create tools and grow to levels impossible in the Stone Age, the technologies of the Iron Age eclipse those of the Bronze, and the pattern repeats throughout recorded history. Yet no technology or scientific advancement arrives totally benign; the iron that allowed soldiers to better protect themselves in battle also allowed the construction of sharper and deadlier swords. In more contemporary times, nuclear physics has unlocked energy reserves previously hidden from humanity, but has brought with it the threat of total nuclear annihilation. No better time period than the early 20th century exemplifies this duality of technology; chemical processes that gave way to new medicines and fertilizers also brought forth chemical weapons and promoted explosives manufacturing.

Our group was interested in the First World War because we viewed the conflict as the inevitable result of technology outpacing contemporary understanding. The war saw the introduction or mass adoption of tanks, chemical weapons, machine guns, planes, and several other technologies, and the result was a war unlike any other in human history. Specifically, our group found an interest in the development, usage, and later disownment of chemical weapons by the major powers in World War I. Our IQP focuses on the change in perspective brought to chemical weapons by the Great War. The conflict initially saw gases as viable alternatives to conventional weapons, yet the end of the war saw those same weapons branded cruel and inhumane—this IQP is centered around understanding why chemical weapons were, and remain, branded as such. Our project was arranged differently than a standard IQP. Rather than focusing

on a modern technology and its effects, our IQP focuses on the historical ramifications of an old technology as to better understand the significance of emerging ones.

World War I took place between the years 1914 and 1918. As no living combatants or eye witnesses to the conflict remain, this IQP utilized both the analysis of documents and artifacts from the period and the examination and study of works written about those documents and artifacts. The primary source documents investigated and discussed were taken as works of their time, written by people who had lived through those events and lacked the knowledge of hindsight. Secondary source documents written at a later date by historians have the benefit of understanding the outcome of each decision in the war, and were useful tools to guide our research and aid our understanding of the overall conflict. Still, our group took special care in cross analyzing secondary sources as to minimize any possible misunderstandings arising from placing a modern interpretation on historic events. The standard of analysis for primary documents was necessarily different than for secondary documents. First hand accounts of the conflict often exaggerated events or, in the case of propaganda, fabricated false figures to further a specific narrative, while historical papers on the era were far less likely to contribute to that false narrative. Analysis of secondary documents was restricted to peer reviewed scholarly articles or journals, to published books, or to interviews with reputable experts on the time period as to allow for proper curation of the data.

As an aside to the main investigation, this IQP also included an exhibition of World War I era artifacts as to both commemorate of the centennial anniversary of the armistice and to gather information about the familiarity of WPI students and faculty with the Great War. The exhibit took place at the Gordon Library on November 9th and 12th, the two weekdays closest to Armistice Day on November 11th. The main display exhibited various uniforms and gas masks

from various countries in the Great War, and also included a short survey for visitors to complete anonymously for data to be collected on the modern understanding of the First World War.

Further, this IQP also included an appendix compiling WPI's activities related to the Great War between 1914 and 1918. Learning about WPI's specific involvement in the fighting allowed our group an understanding of the war on a personal level, while also allowing us a glimpse into the state of American preparedness for the conflict through the lens of a single institution.

The Great War saw the major powers of Europe throw their full might at each other in a mass slaughter that lasted from 1914 to 1918. Chemistry was perverted from a science of healing and creation into a weapon of death and destruction. After World War I was over, the world came to the consensus that poison gases are inhumane and cruel weapons, and decided to never use them again in conflicts. Unfortunately, the decision to ban chemical weapons was only made after hundreds of thousands of people, both soldiers and civilians, were killed by them.

Unfortunately, chemical weapons are often impossible to control on the battlefield; the gases go whichever way the wind blows and are blind to the difference between friend and foe or civilian and combatant. In essence, poison gases are indiscriminate weapons that target both civilians and soldiers alike, but are especially deadly to those who have no form of protection against the weapons. In such cases, gases serve only to compound the suffering of those they are used against.

World War I serves as an example of the danger posed when science ceases to serve humanity and instead serves to destroy it. Still, the threat of war should not deter scientific progress—for every death chemistry dealt in World War I, it has since saved thousands. The Haber-Bosch process that provided Germany its explosives in the Great War has since allowed

billions of people to live without fear of starvation. Scientific advancement cannot be halted, and any attempts to do so will fail. Instead, scientific advancement should be unanimously pursued with the goal of aiding humanity, and never to harm it.

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Part I: The Great War - The History and Analysis of Chemical Weapons

Article Abstract

Chemical weapons are usually classed alongside nuclear and biological arms as highly regulated weapons of mass destruction, yet, historically, chemical weapons have produced surprisingly few deaths on the battlefield. When chemical weapons were used in World War I, though responsible for relatively few casualties as compared with other novel technology, they still gained a reputation as cruel, barbaric, and inhumane weapons. This paper analyzes the use of chemical weapons in World War I through the motives and actions taken by prominent figures in the conflict while anchoring the discussion within the framework of Just War theory. This paper argues that chemical weapons gained their disproportionately horrific reputation through a historical experience involving treaty violations, compounding the inherently indiscriminate nature of gas weapons, which undermined their potential to be used in the service of any "just" war.

Chapter 1: A Lasting Peace - Science and the Philosophy of War

Just War from Antiquity to WWI

On 1 November 1914, Pope Benedict XV wrote the first of his encyclicals to be distributed to the Bishops around the world. The Pope decided to make the first major statement of his Papacy about the war in Europe, which began just a month prior to his election in September of the same year. Benedict XV wrote about the loss of life and the horror of modern war due to the advanced weaponry being employed to accelerate the slaughter:

> The combatants are the greatest and wealthiest nations of the earth; what wonder, then, if, well provided with the most awful weapons modern military science has devised, they strive to destroy one another with refinements of horror. There is no limit to the measure of ruin and of slaughter; day by day the earth is drenched with newly-shed blood, and is covered with the bodies of the wounded and of the slain.[1]

Though the loss of life would only continue as World War I raged on, Pope Benedict noted the death and destruction it had already caused in the first few months of fighting in 1914. The head of the Vatican directly mentioned modern military weapons as being part of the horror of the war, likely referring to artillery and machine guns, since the most infamous weapon of the war, poison gas, had not yet been used. The Pope called for an end to the fighting and bloodshed, and for the leaders of Europe to resolve their dispute in some other way than relentless slaughter.

Benedict's statements expressed a moral reaction rooted in Catholicism's advocacy for Just War Theory. Since antiquity, philosophers around the world have made attempts to form a conclusive ideology that would outline either the justification of a war, the conduct in which that

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[1] Benedict XV. *Ad Beatissimi Apostolorum*. Encyclical Letter. Vatican Website. November 1, 1914. https://w2.vatican.va/content/benedict-xv/en/encyclicals/documents/hf_ben-xv_enc_01111914_ad-beatissimi-apostolorum.html.

war might be fought, or both.[2] In Europe, revered philosophers dating back to Thucydides, Aristotle, and Plato placed conditions upon which a war could justly be waged, yet the ancient Greeks could not form a complete consensus on what these boundaries were.[3] Much later, the idea of pacifism appeared as a common and popular ideology among the philosophers of the medieval era. Pacifism remained strong between the 18th and 20th centuries; one particular 19th century philosopher, Leo Tolstoy, believed that war itself was immoral because it involved the killing of humans by other humans. As a member of the Orthodox Church, Tolstoy questioned his own denomination, "how can so-called enlightened men preach war, support it, participate in it, and, worst of all, without suffering the dangers of war themselves, incite others to it, sending their unfortunate, defrauded brothers to fight?"[4] Tolstoy was later excommunicated from the Orthodox church for his anarcho-pacifist beliefs which were in opposition to the church.[5] Like their ancient counterparts however, modern philosophers could not form a consensus about the topic of just war, and the pacifistic interpretation became one of many prominent theories.

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[2] An ancient Indian epic written in Sanskrit, *Mahabharata*, was written about the Kurukshetra War, and is the longest epic ever written. A major theme in *Mahabharata* is *Dharmayuddha*, most closely translated to "Righteous War" and its contrast with *Kutayudda*, or "Unjust War". A conversation in the epic between five brothers discusses the proportionality of war, a just means of fighting, and a just cause for fighting. For instance, *Mahabharata* discusses how chariots should not attack cavalry, but instead should attack only other chariots. The epic also discusses the fair treatment of prisoners and the wounded, enshrines the safety of noncombatants, and bans the usage of "Divine Weapons" bestowed upon an army by the gods. Kaushik Roy, Hinduism and the Ethics of Warfare in South Asia: From Antiquity to the Present (Cambridge: Cambridge University Press, 2012), 28.

[3] Ancient philosophers such as Thucydides believed that war against invaders was not only just, but should be celebrated, saying that it is a "Most lawful act when men take vengeance upon an enemy and an aggressor". Aristotle believed that a war to conquer uncivilized peoples would also be acceptable, having said war should be brought "against men who, though intended by nature to be governed, will not submit; for war of such kind is naturally just." Plato is more liberal in his interpretation of why a war should be waged, claiming that "at the root of all wars" is the desire of a nation to expand. Plato claimed that when "The original healthy state is no longer sufficient. . . . The country which was enough to support the original inhabitants will be too small . . ." which will lead a country to expand and is a fact of nature that is unavoidable. Joachim Von Elbe, "The Evolution of the Concept of the Just War in International Law,". *The American Journal of International Law* 33, no. 4 (1939): 665-666, doi:10.2307/2192879.

[4] Leo Tolstoy, "Count Tolstoy on the Russo-Japanese War," The Advocate of Peace (1894-1920) 66, no. 9 (1904): 164.

[5] Ivan M. Andreev, "The Excommunication of Leo Tolstoy from the Orthodox Church," *Orthodox Life*, May/June 1961. Some writers of the 18th to 20th centuries started to follow the idea of Positive International Law, which rejects the idea of a "just" and "unjust" war as a whole. Instead of justifying or condemning a war, followers of

Francis Lieber was a notable exception to the general advocation of pacifism among modern philosophers during the 19th century. Lieber was a German born during the French Revolution, whose first foray into battle was against Napoleon in 1815.[6] Though he saw many of his fellow soldiers die, and he himself was wounded at the Battle of Waterloo, Lieber nonetheless claimed it was a positive overall experience.[7] In 1816, Lieber became an advocate of Liberal Nationalism and fled his conservative Prussian government in 1821.[8] Lieber first fled to Rome after hearing about the War of Greek Independence, then to England, and finally to the United States where he lived out the rest of his life from 1827 until his death in 1872.[9]

Lieber believed that war was sometimes not only necessary, but even beneficial under certain conditions.[10] In Lieber's mind, a legitimate war must be short, likely to succeed, must be fought in accordance to terms agreed upon by all warring parties, and should only be fought if the war would bring about a just result.[11] Lieber believed that if all of his conditions for a just war were met, not only should the war be fought, it should actively be sought out by the party in a position to gain from it. Lieber's philosophical ideology, though not necessarily accepted as a whole, has historical precedent in some of its points. In particular, his idea that a just war can

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Positive International Law would claim that the right to declare and conduct war is one inherent to a sovereign state, and so the ability to justify a war is also only possessed by that sovereign state. [Joachim] Von Elbe, ["The Evolution of the Concept of the Just War in International Law,". *The American Journal of International Law* 33, no. 4 (1939)]: 682-683, doi:10.2307/2192879.

[6] Daniel R. Brunstetter and Cian O'Driscoll, *Just War Thinkers: From Cicero to the 21st Century* (London, New York, NY: Routledge, 2018), 181.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Brunstetter, 182.

[11] Brunstetter, 182, 186.

Lieber did not believe in fighting a war for simply for material gain if there was no greater motive involved. He was a supporter of conflicts such as the American Revolution, and believed that ideological differences were a valid reason for fighting a war. Brunstetter, 184.

only be fought on terms agreed upon by both sides is supported by the widespread signing of treaties regulating the conduct of warfare.

Hague Conference of 1899

Between the 12th and 24th days of August, 1898, the Russian Empire under Czar Nicholas II sent a letter to various diplomatic representatives of the major world powers. Count Mikhail Nikolayevich Mouravieff, the Russian Minister of Foreign Affairs, sent the letter as a proposition to hold a peace conference that would be attended by countries around the world. The Foreign Minister wrote that the goal of the conference would be "The maintenance of general peace and a possible reduction of the excessive armaments which weigh upon all nations present themselves."[12] Though Mouravieff had kindled the idea of a peace talk, he had not sent the invitations for any conference just yet. The Foreign Minister's instruction from his Czar was to send the letters out to weigh the interest of the major powers in holding such a conference before actually planning an event.[13] Most major world powers appeared to show an interest in the conference and, on January 11 of the following year, Count Mouravieff sent another message to the powers, informing them of the positive reception of the letter. The Russian government was evidently pleased by the response by the rest of the world and began organizing a conference to be held at The Hague in the Netherlands.[14] Per Count Moravieff's letter, the conference was to

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[12] "Russian Circular Note Proposing the First Peace Conference." Letter from Mouravieff. August 24, 1898. James Brown Scott, *The Hague Conventions and Declarations of 1899 and 1907, Accompanied by Tables of Signatures, Ratifications and Adhesions of the Various Powers, and Texts of Reservations: Edited by James Brown Scott, Director* (New York: Oxford University Press, 1915), xv.

[13] Ibid.

[14] The Hague was chosen to be the location of the conference because the Russian Government did not believe it would be proper for the conference to be held in the capital of one of the great powers. Instead, the Russians sent a request to Queen Wilhelmina of the Netherlands to ask that she grant permission for the conference to be held at The Hague. "Circular Instructions of the Netherland Minister For Foreign Affairs to Diplomatic Representatives. Invitations to the Conference." Letter from Willem Hendrik De Beaufort. April 6, 1899.James Brown Scott, *The Hague Conventions and Declarations of 1899 and 1907, Accompanied by Tables of Signatures, Ratifications and*

discuss several main topics related to not only preventing war, but also to limiting its conduct in the event that war broke out in the future.[15] The official invitations to The Hague Conference of 1899 were sent out to the major world powers on April 6, 1899 by Willem Hendrik De Beaufort, the Minister for Foreign Affairs for the Netherlands.[16] The conference, which was to be held on May 18 of the same year, did not limit the number of attending countries, but Beaufort's letter made a note that each member would have no more than one vote in the proceedings.[17]

The Hague Conference was meant to be, in part, a continuation of the conference held at Brussels in 1874, which was a broad and ambitious attempts to regulate the rules of warfare.[18] The conference at Brussels originated on the basis of a document written by Francis Lieber called the *Lieber Codes*, which Lieber wrote for the United States at the behest of Abraham Lincoln after the conclusion of the American Civil War.[19] The conference at Brussels was designed to ratify, in an international sense, many aspects of the *Lieber Code*, including the handling of prisoners of war, protection of civilians and civilian property, and restrictions on certain forms of weaponry.[20] Although the conference at Brussels was signed by only a small portion of the major powers at the time, it serves as an early glimpse into what many of the discussion points at The Hague Conference would be.[21] The invitation to The Hague did not

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Adhesions of the Various Powers, and Texts of Reservations: Edited by James Brown Scott, Director (New York: Oxford University Press American Branch, 1915), xix.

[15] Mouravieff, *Russian Circular Note Proposing the Program of the First Peace Conference*.

[16] Willem, *Circular Instructions of the Netherland Minister*.

[17] Ibid.

[18] James Brown. Scott, *The Hague Peace Conferences of 1899 and 1907. A Series of Lectures Delivered before the Johns Hopkins University in the Year 1908, by James Brown Scott, ... in Two Volumes. Volume II. Documents*, vol. 1 (Baltimore: Johns Hopkins Press, 1909), 525.

[19] Ibid.
In 2015, the United States Department of Defence published its *Law of War* manual, which explicitly refers to the *Lieber Code* and its influences on the modern document as well as its historical influence.
Department of Defense Law of War Manual. Washington, DC: Office of General Counsel, Department of Defense, 2015.

[20] Attendees of the Brussels Declaration of 1874, *Project of an International Declaration concerning the Laws and Customs of War. Brussels* (Brussels: International Red Cross, 1874).

[21] Scott, *The Hague Peace Conferences*, 525.

name those points directly, but did directly state that a point of discussion would be the "Revision of the declaration concerning the laws and customs of war elaborated in 1874 by the Conference of Brussels, and not yet ratified."[22]

While the concept of The Hague Conferences seemed appealing to most European powers, the talks were not universally praised. Leo Tolstoy was not convinced by the stated purpose of The Hague. In May of 1899, shortly before the peace talks began, Tolstoy wrote "The [Hague] conference itself can be nothing but one of those hypocritical arrangements which aim not at peace, but, on the contrary, at hiding from men the one means of obtaining universal peace, which the foremost men are now beginning to discern."[23] Tolstoy's scathing remarks were aimed at exposing the underlying assumption of The Hague Conference: war is inevitable and unavoidable.

On 18 May, 1899, the conferences at The Hague officially commenced, and on the 29th of July concluded with an agreed upon resolution limiting the rules of war.[24] In particular, the great powers of France, Germany and the United Kingdom all signed sections of The Hague Conference which regulated warfare, three points of which would have great significance later, during the First World War.[25] The first two points are found in Section II of The Hague Conference, which state "Besides the prohibitions provided by special Conventions, it is especially prohibited - (a.) To employ poison or poisoned arms; . . . (e.) To employ arms, projectiles or materials of a nature to cause superfluous injury." The third point can be found in

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[22] Mouravieff, *Russian Circular Note Proposing the Program of the First Peace Conference*.
[23] Leo Tolstoy, "Count Tolstoy's Opinion of the Peace Conference," *The Advocate of Peace (1894-1920)* 61, no. 5 (1899).
[24] Certain sections of the document were not signed by some of the major powers. For instance, France, Germany, and the United Kingdom signed Section IV Article II of The Hague which dealt with gas warfare, but the United States did not. Similarly, the United Kingdom declined to sign Section IV Article I which dealt with the dropping of bombs from air balloons, but Germany and France both signed this section.
Scott, *The Hague Peace Conferences*, 231.
[25] Scott, *The Hague Peace Conferences*, 231.

Section IV, written "To prohibit the use of projectiles the only object of which is the diffusion of asphyxiating or delirious gases."[26] These points were signed by the major powers in 1899, and the second point was agreed upon again in 1907 because its original implementation within the 1st Hague Conference was designed to invalidate itself after five years.[27]

Chemistry in Agriculture

In June of 1898, Sir William Crookes, a British chemist famous for his recent discovery of the new element Thallium, spoke at the gathering of the British Association for the Advancement of Science in Bristol. Rather than speaking about his recently discovered element or another aspect of his research, Crookes issued a warning for Western civilization. Crookes foretold the impending mass-starvation of Western society due to its dependence on quickly depleting fertilizers to feed its people:

> It is of urgent importance to-day, and is a life-and-death question for generations to come. Many of my statements you may think are of the alarmist order . . . but they are founded on stubborn facts. They show that England and all civilized nations stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena. . . . our wheat-producing soil is totally unequal to the strain put upon it.[28]

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[26] *The Hague conventions of 1899,* Section II Chapter I Article 23; Scott, *The Hague Conventions and Declarations*, 116; *The Hague conventions of 1899,* Section IV 2; Scott, *The Hague Conventions and Declarations*, 26.
[27] The wording of the second point changed in 1907 to read "(e.) To employ arms, projectiles, or materials calculated to cause unnecessary suffering;" Scott, *The Hague Peace Conferences*, 116.
[28] William Crookes, "Address of the President Before the British Association for the Advancement of Science, Bristol, 1898," *Science* 8, no. 200 (1898): 562, doi:10.1126/science.8.200.561.

While Crookes began his speech with a rather grim and depressing sentiment, he used his position as speaker to implore the chemists around the world to find a solution to the Nitrogen issue. Crookes believed that the solution would not be found in a natural way, but that "It is through the laboratory that starvation may ultimately be turned into plenty."[29] Years later, a German chemist named Fritz Haber would eventually discover the means to turn atmospheric Nitrogen into usable ammonia while another German, Carl Bosch, would turn Haber's laboratory experiment into a large scale operation within the German chemical giant, BASF. Though Bosch's ammonia factories saw many setbacks, the chemical plants were fully operational by the winter of 1913. BASF saw profits soar as hundreds of tons of synthetic flowed from its factory at Oppau, and the Haber-Bosch process, as it would come to be known, would transform Western agriculture into a highly sophisticated patron of the chemical industry.

The early 20th century appeared as though it was the beginning of an era of peace and prosperity. With the First Hague Convention in 1899, followed by the Second Hague Convention in 1907, and a third meeting planned for 1915, peace was on the minds of many world leaders and military powers at the start of the century.[30] BASF's new chemical plant at Oppau began producing synthetic ammonia at a rate high enough to quell fears about the downfall of Western agriculture, and the future of Europe seemed full of promise.

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[29] Ibid.

[30] James Brown Scott, *The Hague Conventions and Declarations of 1899 and 1907, Accompanied by Tables of Signatures, Ratifications and Adhesions of the Various Powers, and Texts of Reservations: Edited by James Brown Scott, Director* (New York: Oxford University Press American Branch, 1915), xiii.

Chapter 2: Lighting the Powder Keg - The Advent of Modern War

The Shots that Sent the World to War

On June 28, 1914, Austro-Hungarian Archduke Franz Ferdinand and his wife were assassinated in Sarajevo by Serbian national Gavrilo Princip. Two bullets were all that was necessary for Austria-Hungary to declare war against Serbia, culminating in a war of alliances that pit Austria-Hungary and Germany against Serbia, Russia, and France. A century of relative peace in Europe had ended and the Great War (or the War to End All Wars) had begun.

The outbreak of war should not have been a surprise to anyone; the "peace" talks at The Hague had been initiated with the notion that war was an inevitability, a fact that was not lost upon pacifists like Leo Tolstoy.[31] Even fairly recent European history showed long term peace was impossible. As new, deadly weapons were being designed and multiple minor conflicts had already broken out in and around Europe since the turn of the century, Europe was gearing up for a major bloodbath—even as the continent planned and held its Hague Conventions.

Modern Arms: Gatling and Maxim

In the 1860's, Richard Jordan Gatling finalized his work on a new model of firearm and hoped to sell it to the United States government.[32] The Gatling gun was the first modern machine gun; it was crank operated and allowed a soldier to fire shots faster than any other weapon at the time. Though the Gatling gun did not receive much attention from the United States, it heavily intrigued other militaries around the world. By 1876, Russian troops were equipped with

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[31] Tolstoy, "Count Tolstoy on the Russo-Japanese War," 66.
[32] Max Boot, *War Made New*: Technology, Warfare, and the Course of History, 1500 to Today (New York: Gotham Books, 2006), 150.

approximately 400 Gatling guns, and used them to great effect in the Russo-Turkish War.[33] No other weapons could match Gatling guns in terms of fire rate, but the awkward crank mechanism required to fire the weapon meant that it was not truly automatic.

Hiram Maxim, another American inventor, took up the challenge of designing a fully automatic machine gun that could be operated with the simple pull of a trigger. Maxim was not known for creating firearms while he was working on his machine gun in the 1880's; he had previously invented domestic items such as a curling iron and lightbulb.[34] Maxim's focus changed when he spoke to an American colleague during a visit to Vienna in Austria-Hungary, who had told Maxim, "Hang your chemistry and electricity! If you want to make a pile of money, invent something that will enable these Europeans to cut each other's throats with greater facility."[35] Maxim eventually succeeded in his endeavor; his completed Maxim gun operated at a higher firing rate than the Gatling gun without the need for an awkward mechanical crank. Despite the clear advantages of the Maxim gun, however, many military powers were slow to adopt it.[36]

The British army was the first military force to adopt the Maxim gun, though it did not do so in large quantities. The United Kingdom purchased its first Maxim guns in 1887, and by 1890 had planned for each battalion to have one Maxim gun for training, but internal opposition in the military meant the integration progressed much slower than planned.[37] By 1894, there were still many units without Maxim guns, and most soldiers were still training on old crank operated

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[33] Russia had tested and ordered 20 Gatling guns in 1865. They ordered 70 more in 1868, and later that year were given a license to manufacture Gatling guns in Russia, which they called *Gorloffs*.
John Ellis, *The Social History of the Machine Gun* (Baltimore, MD: John Hopkins Univ. Press, 1987), 66.
[34] Boot, 150.
[35] Ibid.
[36] When Maxim showed his weapon to the Russian military, they had asked him what the rate of fire of the weapon was. After Maxim answered their question, the Russians, who had grown accustomed to the crank-fire Gatling Gun, questioned how a soldier was expected to possibly crank the weapon so fast. Ellis, 66.
[37] Ibid.

Nordenfelt and Gardner guns.[38] In Germany, the Kaiser was incredibly interested in the Maxim, claiming in 1902 that a battalion with machine guns could put an entire army corps in check.[39] Maxim entered a twenty year sales agreement with Germany in 1888, and negotiated a seven year manufacturing licensing agreement in 1892.[40] The gun sold extremely well in Germany, and Maxim also found great success for his weapon in Russia.[41] After a demonstration of the weapon, the Russian military was so impressed that it began incorporating Maxim guns into its ranks the same way it had with the Gatling only a few decades earlier.[42] By 1904, each Russian division had a machine gun company comprised of eight Maxim guns. The power of the Maxim would soon be on display for the entire world to see.

New Lessons in the Context of Modern War

The Russo-Japanese War began on February 8, 1904, and should have been an early indicator of how war would look in the twentieth century. Observers from America and across Europe were sent to the battlefields to analyze the fighting, and many made note of the new machine guns that were used. Some observers saw how effective machine guns could truly be, with one German writing, "In less than two minutes [the Russians] fired about a thousand

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[38] Ibid, 65; Martin Pegler, The Vickers-Maxim Machine Gun (Oxford: Osprey Publishing, 2013), 18-19. The Maxim gun was fairly unpopular in Britain when it was first introduced. Some soldiers even showed a preference for the outdated Gardner gun, which weighed more than twice that of the Maxim and had a lower accuracy and fire rate. Initially, the Maxim was received quite poorly outside of the UK; when Maxim had traveled to Constantinople to offer his weapon to the Turks, he was told "Hang your guns, we don't want your guns." Even Maxim's personal military advisor, who Maxim referred to as Captain X in his autobiography, stated "Guns were not as a rule made for actual warfare, but for show . . ." and described Maxim's design for a non-recoiling field gun as "Extremely ugly as compared with the graceful form of existing guns." Ellis, 65.

[39] Ibid, 61. Ironically, Wilhelm had first seen the machine gun at the recommendation of a member of the British Royal Family. Ibid.

[40] Pegler, 20. Germany's purchase of Maxim guns were crucial to Maxim's company's early success. After the manufacturing licensing agreement between Maxim and Germany expired, the Germans developed and manufactured their own variant of Maxims gun. Ibid, 20, 24.

[41] Maxim also saw varying levels of success for his guns in other countries. Namely, France, Australia, Spain, and Italy all ordered Maxim guns in 1889. Ibid, 18-20.

[42] Ellis 66.

rounds, and the Japanese firing-line was literally swept away."[43] Others felt that machine guns were still effective, but not overly so. A British correspondent who had spent most of the war with the Russians, Maj. Montgomery Macomb, said machine guns "played a useful but not great part in the war." He claimed that a machine gun could do the job of only 50 men, not the 100 that some claimed. Further, Macomb noted each machine gun required 12 men to operate properly, meaning each machine gun only yielded a net positive of about 38 infantrymen as opposed to the advertised 99.[44] Still, some military traditionalists seemed to completely disregard the tactical uses of machine guns in favor of infantry, with American Captain William V. Judson remarking, "nothing in the Russo-Japanese War demonstrated that, in field battles, the infantry had lost its supreme importance."[45] Attitudes like Judson's were not uncommon, especially among the French, who still followed the lessons of the Boer War; that nothing could stop an offensive led by highly trained infantry—a lesson that would lead to the deaths of tens of thousands of Frenchmen during the early months of the Great War.[46] The Russo-Japanese War officially ended on September 5, 1905, less than a decade before the start of one of the largest war in European history.

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[43] Ibid, 67.
[44] John T. Greenwood, "The American Military Observers of the Russo-Japanese War (1904-1905)," *Army History* 36 (1996): 6.
[45] Ibid, 3.
[46] Ibid. The French did not take part in the Boer War, but were still able to observe the effectiveness of infantry during the fighting.

France, Germany, and Neutral Belgium

The date that marks the beginning of World War I is still a subject of debate. The assassination of Archduke Ferdinand took place on June 28, 1914. The declaration of war by Austria-Hungary and Germany on Serbia took place on July 28 of the same year. Germany declared war on Russia on August 1st, declared war on France on August 3rd, and on August 4th invaded neutral Belgium, causing the United Kingdom to declare war on Germany that same day. August 4th marked the last declaration of war between major powers on the Western Front for nearly 2.5 years, and the events of that day would mark the tone of the rest of the war.

Of the countries that entered into the early war, Belgium was the only entity to be attacked that had no direct interest in the conflict that had erupted.[47] France had publicly stated on July 31st "No incursion of French troops will take place into Belgium . . . France would not like to have the responsibility of committing in regards to Belgium the first act of hostility."[48] Still, Germany sent a note to Belgium on August 2nd indicating that it believed France would attack through Belgium, and that Germany would be "under the obligation to prevent that attack and to violate Belgian territory." The letter requested that Belgium treat Germany as friendly, and stated that Belgium had twelve hours to reply.[49] That same day, Sir Edward Grey in the British House of Commons sent a telegraph to both Paris and Berlin requesting information about each country's position on Belgian neutrality. France responded in a similar way to its statement on July 31, and Germany replied "The Secretary of State for Foreign Affairs could not

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[47] Germany and Austria-Hungary had joined the war together against Serbia. Russia had been allies with Serbia, while France had strong ties to Russia as part of the Franco-Russian Alliance. The Triple Entente between Russia, France, and Britain also linked Britain into the war, though Britain only declared war after the German invasion of Belgium.

[48] "Special Cable to THE NEW YORK TIMES.BELGIUM'S CASE TO THE WORLD," *New York Times*, October 6, 1914.

[49] Ibid.

possibly give an answer before consulting the Emperor and the Imperial Chancellor." Later, the German Minister for Foreign Affairs indicated that he may not be able to give a direct answer at all, as the answer might give away Germany's campaign tactics.[50] Two days later, Germany violated Belgian neutrality and marched its armies across the border, drawing the United Kingdom into the war.[51] There is no historical question regarding why Germany had violated Belgian neutrality in the beginning months of World War I; the attack through Belgium was necessitated under the Schlieffen Plan, which aimed at knocking France out of the war as quickly as possible by flanking Paris via an attack through Belgium.

Kriegsraison: The Necessity of War

Germany likely adopted the Schlieffen Plan in the first place because its military leaders strongly followed the Clausewitzian doctrine of *kriegsraison*. Prussian General Carl von Clausewitz, who lived from 1780 to 1831, was an influential war theorist whose unfinished book, *Vom Kriege*, or *On War*, focused on the philosophy of war and battle, with his most famous quote "War is just the continuation of politics by other means." Clausewitz's ideas were taken by many to dictate that "absolute war" was a necessary military doctrine, and his works were popular around the world, especially in Germany.[52] The fifth edition of *Vom Kriege* was released in Germany in 1905, and contained a foreword by Chief of Staff Alfred von Schlieffen,

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[50] UK Parliament, "Sir Edward Grey's Speech before the House of Commons," *Parliamentary Debates, Commons*, 5th ser., 65 (1914):.

[51] Ibid. On August 3rd, a day before the British declared war on Germany, Sir Edward Grey indicated that the United Kingdom would only declare war in two cases: If Germany used the English Channel to attack the Northern coast of France, or if Germany violated Belgian neutrality. Germany replied to the former by indicating that they would not attack the Northern coast of France if Britain pledged its neutrality, but then attacked Belgium the next day and drew Britain into the war anyways.

[52] Hew Strachan, "The 2010 George C. Marshall Lecture in Military History: Clausewitz and the First World War," *Journal of Military History* 75, no. 2 (April 2011): 367.

the mastermind behind the Schlieffen Plan.[53] In 1914, *Vom Kriege* reached its peak popularity since its release in 1832, and the doctrine of *Kriegsraison*, based on Clausewitz's works and most closely translating to "the necessity of war" was alive and well in Germany. [54]

Kriegsraison follows the idea that the outcome of a war is more important than the manner in which the war is fought. The idea is sometimes expanded to read *kriegsraison geht vor kriegsmanier*, most closely meaning "the necessity of war overrides the way of fighting a war," and signifies an ideology that is the antithesis of Just War theory.[55] The 1904 German Military Code for the Conduct of War on Land noted a possible incompatibility between its heavily emphasized military necessity and "exaggerated humanitarian ideas."[56] Those "humanitarian ideas" would likely vary depending on who was asked; a pacifist such as Tolstoy might argue that a war could never be justly fought, while a disciple of Lieber might instead offer that a war might be just if fought under certain circumstances. These two ideas hold that certain actions cannot be taken within a just war, but a disciple of *kriegsraison* would argue that the morals behind a war are irrelevant so long as the outcome is beneficial to the one waging it.

The decision made by the German high command, the *Oberste Heeresleitung*, or OHL, to enact the Schlieffen Plan directly violated a treaty to uphold Belgian neutrality that had been signed by Germany. Helmuth von Moltke the Younger, Chief of Staff and head of the OHL at the beginning of the war, likely believed that the tactical advantage projected by the Schlieffen Plan far outweighed the political ramifications of attacking a neutral country. The decision to

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[53] Ibid, 369.
[54] Th. Niemeyer, "International Law in War," *Michigan Law Review* 13, no. 3 (1915): 178, doi:10.2307/1274546.; Strachan, 371-373.
[55] David Turns, "Military Necessity," *Oxford Bibliographies Online Datasets*, 2012, doi:10.1093/obo/9780199796953-0008.
[56] Nicoletta F. Gullace, "Sexual Violence and Family Honor: British Propaganda and International Law during the First World War," *The American Historical Review* 102, no. 3 (June 1997): 741.

invade Belgium fits perfectly within the framework of *kriegsraison*, as the OHL sacrificed some "humanitarian ideas" for what they deemed a military necessity. Though Germany's attack through Belgium allowed them to circumvent French defences at its border, Germany still faced the monumental task of storming through both Belgian and French forces on its march to Paris.

The Slaughter in Belgium and the Beginning of Trench Warfare

Beginning on August 25, 1914, German troops stationed in Louvain, near Brussels, accused the Belgian populace of taking up arms against Germany. German forces destroyed a significant portion the town, burning the medieval library and executing approximately 248 Belgian civilians.[57] The Burning of Louvain would soon become one of the most infamous episodes in the events that would later be known as the Rape of Belgium. Louvain was quickly used by the Allies as propaganda against Germany, however, many in Germany believed the Allied claims of German war crimes were unfounded. In October, 1914, prominent German scientists, scholars, and artists offered their full support to Germany's military by drafting and signing the *Manifesto of the Ninety-Three* to rebuke what they believed to be Allied lies.[58] Still, as political pressure mounted against Germany, its forces pushed across Belgium and into France, intending to capture Paris and fulfill its promise that the war would be over before Christmas with a German victory.

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[57] John Horne and Alan Kramer, *German Atrocities, 1914: A History of Denial* (New Haven, CT: Yale University Press, 2001), 76.

[58] Professors of Germany, "To the Civilized World," *The North American Review* 210, no. 765 (August 1919): 284-287. Fritz Haber was among the signatories of the *Manifesto of the Ninety-Three.* One of the 93 German Professor signatories of the manifesto, Wilhelm Foerster, regretted his signing and actually created a new document called the *Manifesto to the Europeans*, but the document was never published as only two other people signed it. One of the other people who signed Foerster's document, and the person who later revealed its existence, was Albert Einstein. Siegfried Grundmann and Ann M. Hentschel, *The Einstein Dossiers: Science and Politics - Einsteins Berlin Period with an Appendix on Einsteins FBI File* (Berlin: Springer, 2010), 29-32.

Germany marched through Belgium fairly quickly and delivered several crushing defeats to the Allied forces in the early stages of the war. The French, specifically, saw 75,000 killed in August, with the worst of the fighting occuring during the Battle of the Frontier, the name given to a collection of battles that occured from August 20 to August 24. On August 22 alone, France suffered 260,000 casualties, with 27,000 killed, the greatest loss of life on a single day in French military history.[59] Still, Germany suffered many losses of its own during those months, but continued to press forward until the First Battle of the Marne, when an Allied counterattack halted their progress on September 6. By September 12, the German army was forced to retreat North to the Aisne river where stalemates against the British forced Germany to dig the first major trenches of the war, culminating in the famous "race to the sea" and the beginning of trench warfare. If either side wished to end the war quickly and with a definitive victory, new tactics and technologies would have to be adopted to fight what had settled into a predominantly defensive war.

[59] D. Stevenson, *1914-1918: The History of the First World War* (London: Allen Lane, 2004), 54.

Chapter 3: Ypres - The Birth of Gas Warfare

Early Chemical Development

On October 27, 1914, approximately 3,000 German chemical shells bombarded the British lines around Neuve Chapelle in the Artois region of France. The so-called "Ni-shells" were standard German fragmentation shells that contained a powdered mix of dianisidine salts designed to be irritating to the eyes and lungs.[60] The Germans hoped that their Ni-shells would be able to force the British soldiers out from houses or other defensible positions, yet the chemicals did not produce the desired effect. The German shells proved to be so ineffective that Allied intelligence was unaware of their existence until the plans were discovered in German documents after the war.[61]

Germany was not the only country to use chemicals in a military form during the first few months of the First World War. Prior to the use of Ni-shells, the French used irritating gases similar to modern tear gas as early as August, 1914, which marked the first use of gas weapons in the war.[62] The French *cartouches suffocantes* were special canisters filled with a highly volatile liquid, ethyl bromoacetate, that had been designed and used for domestic crowd control before the war by the French Police in 1912.[63] France was actually the only major power in the war that had a stockpile of gas shells prior to the start of the conflict; many of the other powers had very limited chemical research leading into the war.[64] The French continued to develop their lachrymatory agent, or tear gas, as the war progressed. By February, 1915 French scientists had developed hand-held grenade canisters called *grenades suffocantes*, which contained a higher

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[60] Ulrich Trumpener, "The Road to Ypres: The Beginnings of Gas Warfare in World War I," *The Journal of Modern History* 47, no. 3 (1975): 465, doi:10.1086/241340.
[61] Rudolf Hanslian, *Der Chemische Krieg*, 2 Vols, 3d ed. (Berlin,1937), 1:12; (as cited in Trumpener, 465.)
[62] Michael Freemantle, *Gas! Gas! Quick, Boys!: How Chemistry Changed the First World War* (Stroud, Gloucestershire: Spellmount, 2013), 122.
[63] Ibid.
[64] L. F. Haber, *The Poisonous Cloud: Chemical Warfare in the First World War* (Oxford: Clarendon Press, 1986), 21.

concentration of the same chemical, though it is unclear whether they were ever used in combat.[65]

Unlike France, Germany did not enter into the war ready to use gases in combat. The German military had investigated the possible use of gas weapons before August 1914, but the research from the prewar trials proved so ineffective that it might have have made Germany reluctant to perform additional research during the war.[66] German gas research began again in the latter half of September 1914, shortly after the replacement of Helmuth von Moltke by Erich von Falkenhayn as Chief of Staff. In October, Falkenhayn tasked Max Bauer, then Chief of the Heavy Artillery, to assemble a small team of scientists and army officers at the Wahn artillery range near Cologne.[67] Bauer's team quickly designed and implemented their "Ni-shells" in a single month, which might have been a remarkable feat if the result had not proved such a resounding failure.[68] After approximately 17,000 more shells were created, the project was abandoned by the OHL.[69]

In November 1914, Hans Tappen, a chemist whose brother was an advisor to Falkenhayn, advocated to the OHL the use of liquid xylyl bromide in artillery shells.[70] Production of the xylyl bromide, codenamed "T-Stoff," began in December 1914 at Bayer and Kahlbaum facilities, and

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[65] Trumpener, 462. The British were not as early to produce and deploy lachrymatory gases as France and Germany. In 1915 the Imperial College of London, after being requisitioned by the ministry of munitions, took samples of the French and German lachrymatory gasses and started to test and produce their own lachrymatory gasses. Rafaelle M. Nicholson and John W. Nicholson, "Martha Whiteley of Imperial College, London: A Pioneering Woman Chemist," *Journal of Chemical Education* 89, no. 5 (2012): 600, doi:10.1021/ed2005455.

[66] A. Fries and Clarence J. West, *Chemical Warfare* (New York: McGraw-Hill, 1921), 10; Haber, *The Poisonous Cloud*, 20.

[67] Trumpener, 464.

[68] Someone at the meeting, suspected to be Louis Duisberg but unconfirmed, suggested using dianisidine chlorosulfonate because it was easily obtainable from Leverkusen in a dye manufacturing process. Haber, *The Poisonous Cloud*, 24-25.

[69] Trumpener, 465.

[70] Bauer had also considered the use of xylyl bromide but believed that a liquid within a shell would cause the shell to be unstable in flight. Tests were ordered by Tappen's brother, and the results showed that the liquid was not a major problem. Haber, *The Poisonous Cloud*, 24-25.

shell filling began in January 1915.[71] The T-Stoff shells were first used against the Russians at Bolimów in what is now central Poland on January 31, 1915, but, due to the extremely cold weather, the xylyl bromide did not vaporize and the shells had negligible impact on the enemy.[72] The Germans tried to compensate for the cold by using a mixture of T-Stoff and B-Stoff, also called bromoacetone. In March the combined shells were used against the French at Nieuport, and, for the first time, victims of the gas actually noticed something unusual about the German shells.[73]

While the initial development of T-Stoff was still underway, Fritz Haber, famous for his prewar work on synthetic ammonia, advocated a different substance to the OHL. Haber had been present at the initial testing of T-Stoff, and came away unimpressed by the demonstration, believing that tear gas would be useless on a small scale.[74] His initial idea to correct the issue with tear gas was to fire the gas shells from grouped mortars, but the lack of available supplies made his scheme impossible.[75] Haber's next idea was to use chlorine released from cylinders, which gained much more interest from the OHL. Both the chlorine and the cylinders already existed since chlorine was an important reagent in the German dye industry.[76] Haber described chlorine as a "lung irritant" and claimed that it would work much more effectively than tear gas

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[71] Each tear gas chemical was given a different code letter to distinguish them from each other. The letter "T" was assigned to xylyl and benzyl bromide in reference to Tappen's contribution.
Trumpener, 465.
[72] Haber, *The Poisonous Cloud*, 25.
[73] Ibid.
[74] Trumpener, 466.
[75] Haber, *The Poisonous Cloud*, 27.
[76] War had disrupted the dye industry in Germany, so many of the facilities that made chlorine were either shut down or underutilized by 1915. Not only did Germany have a large supply of chlorine, but they had a reliable way to keep getting more.
Diarmuid Jeffreys, *Hell's Cartel: I.G. Farben and the Making of Hitler's War Machine* (Henry Holt &, 2010), 69.

for clearing out trenches.[77] By the end of 1914, Fritz Haber had been promoted from a Non-Commissioned Officer in the Reserve to the rank of Captain.[78]

Chlorine at the Front

> [I]t was on the afternoon of my birthday that we noticed volumes of dense yellow smoke rising up and coming towards the British trenches. We did not get the full effect of it, but what we did was enough for me. It makes the eyes smart and run. I became violently sick, but this passed off fairly soon. . . .The next thing I noticed was a horde of Turcos (French colonial soldiers) making for our trenches behind the firing line; some were armed, some unarmed. The poor devils were absolutely paralysed with fear.
>
> -L/Cpl J. D. Keddie, H Coy., 48th Royal Highlanders of Canada.[79]

April 22, 1915 began as a warm sunny day at Ypres in Belgium. An innocuous breeze blew from the German position in the North to the Allied trenches in the South at the Ypres Salient.[80] At approximately 5:00 PM, Germans at the Northern end of the salient opened canisters of pressurized liquid chlorine, which when exposed to the atmosphere were instantly vaporized and propelled towards the Allied position by the wind.[81] Some soldiers hit by the gas were severely wounded and fell comatose, while others struggled to breathe as the gas flowed into their trenches, forcing many soldiers to abandon their posts.[82] The Germans quickly advanced from their positions at the center of the assault, but their attacks from the sides proved to be far less effective.[83] German soldiers were cautious of the gas their side had released and advanced slowly behind the cloud, hindered mainly by patches of gas that had been left behind in

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[77] Trumpener, 466.
[78] Haber, *The Poisonous Cloud*, 27.
[79] Lyn Macdonald, *1915, the Death of Innocence* (Baltimore: Johns Hopkins University Press, 2000), 194.
[80] Ibid, 192.
[81] Trumpener, 476. Robert Harris, Joshua Lederberg, and Jeremy Paxman, *A Higher Form of Killing: The Secret Story of Chemical and Biological Warfare* (New York: Hill and Wang, 1982), 4.
[82] Herbert F. Manisty, "The Use of Poison Gas in War," *Transactions of the Grotius Society 9* (1923): 17.
[83] Trumpener, 477.

the craters and troughs of the battlefield.[84] The Germans concluded April 22 with the capture of Langemark and Pilken along with approximately 2,000 prisoners and 51 guns, but by April 23 the advance once again felt major resistance from the Allies.[85] The casualties from the battle are disputed, with British estimates showing approximately 5,000 casualties, while the Germans initially claimed it caused near 15,000 casualties, and some writers of the time estimated 20,000 casualties with 5,000 killed.[86]

The ideology of *Kriegsraison* was likely a large contributor to Germany's decision to use chlorine at Ypres. Germany, like most other countries at the time, had planned for the Great War not only to be great, but to be short, perhaps even concluded by Christmas, 1914. Germany's strategic resource stockpile reflected their expectation of a short war, and as Christmas passed and 1915 arrived, British blockades put Germany in grave danger of running out of supplies that could only be found overseas.[87] Specifically, Germany needed gunpowder and bombs, both of which could be created from their quickly diminishing supply of Chilean nitrates or alternatively, as Fritz Haber noted, from nitric acid.[88] Haber believed that the ammonia he had helped create could be turned into nitric acid, though many at BASF thought large scale manufacturing was not possible. Still, BASF, at the behest and funding of the German government and armed with knowledge of the potential profitability of nitric acid, undertook the challenge of creating nitric

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[84] Haber, *The Poisonous Cloud*, 34; Lester Stevens, "Interview with Lester Stevens: 8th Battalion," interview by Frank Lalor, *Flanders Fields*, Canadian Broadcasting Corporation, 1964. Germans suffered heavy casualties during the advance in certain areas. One first hand account had a machine gunner killing so many Germans that the pile of bodies was too high for the machine gun to shoot over. John Uprichard, "Interview with John Uprichard: 8th Battalion," interview by Frank Lalor, *Flanders Fields*, Canadian Broadcasting Corporation, 1964.

[85] Haber, *The Poisonous Cloud*, 34.

[86] After publishing their initial claims, Germans argued that the Allies inflated their numbers for propaganda purposes.
Valerie Adams, *Chemical Warfare, Chemical Disarmament* (Bloomington: Indiana University Press, 1990), 30.

[87] Jeffreys, 64.

[88] Thomas Hager, *The Alchemy of Air: A Jewish Genius, a Doomed Tycoon, and the Scientific Discovery That Fed the World but Fueled the Rise of Hitler* (New York: Broadway Books, 2009), 137.

acid from their synthetic ammonia.[89] Carl Bosch, who discovered how to upscale Haber's nitrogen work to an industrial level, was chosen by BASF to head the project, but the transition from ammonia to nitric acid was excruciatingly slow. Bosch's progress at the start of 1915 began to worry the OHL, who were no longer confident that BASF would be able to produce the nitric acid at the required rate to conduct the war, so the high command began to search for a new tactic to end the war before Germany's resources were exhausted.[90] Fritz Haber's idea to use Germany's industrial chlorine promised a solution that would not only result in a new weapon, but one that would do so without further draining German resources. While the OHL had decided to use chlorine in a desperate attempt to avoid defeat by attrition, the attack ironically proved unnecessary. On May 1, 1915, nine days after the chlorine attack at Ypres, Carl Bosch announced that BASF's plant at Oppau was capable of producing nitric acid on a scale necessary to supply the war effort.[91]

The Allied response to Ypres was nothing short of scathing. John French, Commander in Chief of the British Expeditionary Force said "The enemy just missed colossal success rendered possible by the use of an entirely new war method; one contrary to engagements entered into by them at the Hague Convention."[92] French was indisputably correct on his first statement; Germany had indeed missed a colossal success, but just barely. Some soldiers at Ypres reported knowing that the approaching gas was chlorine, and by April 24 the Allies were already distributing makeshift gas masks made from rags soaked with water or urine, neither of which

[89] The deal between BASF and the German government stated that Germany would provide BASF with six million marks to create a new chemical plant, but BASF had to supply at least five thousand tons of nitric acid monthly by May 1915. Jeffreys, 66.
[90] Jeffreys, 67.
[91] Jeffreys, 74.
[92] Manisty, 17.

would have been an effective counter to a gas such as phosgene.[93] To French's second point, Germany had indeed been a signatory of the 1899 and 1904 Hague Conventions, both of which placed restrictions on the use of gas and poisonous weapons, but the terms of the agreements were vague and nebulous.[94]

Falkenhayn and other leaders at the OHL had not simply ignored German commitments under the Hague Convention, but instead skirted negotiators' intentions by interpreting the wording of the document quite literally. For instance, the Hague Conventions restricted the use of "projectiles the only object of which is the diffusion of asphyxiating or delirious gases." German chlorine used at Ypres was not delivered in the form of a projectile; instead, it was simply exposed to the air and carried by the wind.[95] Similarly, the Hague Conventions restricted the use of "poison or poisoned arms," but the German high command believed that this restriction applied to poisoned weapons or the poisoning of a water supply, since asphyxiating and delirious gases were already accounted for under an entirely separate restriction.[96] Further, Germans contended that the early French use of their own projectile-based *cartouches suffocantes* without retribution was a clear indication that the Allies also viewed the Hague

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[93] Uprichard; Adams, 30-31. Fritz Haber's son, Ludwig Haber, writes in his book, *The Poisonous Cloud* that two main problems occured with the assault. First, L. Haber writes that his father had not accurately foreseen the impact that not equipping German soldiers with proper defensive equipment would have. Secondly, L. Haber writes that instead of chlorine, phosgene should have been used in the assault because it would have been much more efficient and faster acting than chlorine. Both of Fritz Haber's decisions were likely influenced by time constraints rather than lack of knowledge on the subject matter, as Germany had a plentiful supply of chlorine at the time, but did not have a stockpile of phosgene, nor did it have the protective equipment to outfit its soldiers.
Haber, *The Poisonous Cloud*, 27-28.

[94] Refer back to "Chapter 1: Hague Conference of 1899"

[95] *The Hague conventions of 1899,*Section II Chapter I Article 23.Scott, *The Hague Conventions and Declarations*, 116, *The Hague conventions of 1899,*Section IV 2.Scott, *The Hague Conventions and Declarations*, 26.
The Ni-shells and the various "-Stoff" shells also technically skirted this provision within The Hague Conventions because they were designed to be primarily fragmentary. Since The Hague Conventions specified "[T]he only object of which," Falkenhayn and the other OHL leaders could argue that projectiles of a dual purpose would not be restricted. Trumpener, 468.

[96] Trumpener, 468.

Convention in such a narrowly literal interpretation.[97] Germany responded to the outcry over their chlorine attack at Ypres mainly by comparing the actions of France in 1914 to their own. Inside of the instructions for their tear gas, France had informed its soldiers that the *cartouches suffocantes* were not dangerous at the small concentrations that would occur in a trench. In June, 1915, a German Ministry of War justification for the use of chlorine gas cited those French instructions and drew the implication that the tear gas would be lethal in larger concentrations. The German riposte to Allied outrage chided, "What hypocrisy when the same people grow 'indignant' because the Germans much later followed them on the path they had pointed out!"[98]

Escalation of Gas Warfare and the Introduction of Phosgene

Shortly after the Second Battle of Ypres, Crown Prince Rupprecht of Bavaria, commander of the German Sixth Army wrote in his journal "I made no secret of the fact that the new gas weapons seemed not only disagreeable but also a mistake . . . the enemy would have recourse to the same means, and with the prevailing winds he would be able to release gas against us ten times more often than we against him."[99] Time soon proved the commander correct when, on September 25, 1915, the British conducted a chlorine attack of their own at the Battle of Loos, marking the first use of a poisonous chemical weapon by an Allied power in the war. The chlorine was delivered by the same method that the Germans had delivered it at Ypres, but the British soon began development of a mortar that would be able to fire specially made gas shells, though it is unclear if or when they intended to use it.[100] The genie was out of the bottle,

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[97] Ibid.
[98] Charles F. Horne, Walter F. Austin, and Leonard Porter Ayres, *Source Records of the Great War* (New York: National Alumni, 1923), 138.
[99] Jeffreys, 72
[100] Kim Coleman, *A History of Chemical Warfare* (Basingstoke: Palgrave Macmillan, 2005), 27.

or perhaps more appropriately, the chlorine was out of the canister, and The Great War had now become just as much a war among chemists as it was between generals and monarchs.[101]

Germany took the next step in the escalation of gas warfare with the introduction of phosgene into the battlefield. On December 15, 1915, German soldiers discharged 177 tons of a mixture of phosgene and chlorine codenamed "D-Stoff" against British troops at Flanders.[102] Though the British were better prepared for a gas attack after Ypres, phosgene is more toxic and dense than chlorine, which enabled the gas to more easily sink into trenches. Additionally, phosgene does not have an unpleasant smell, and so some soldiers poisoned by the gas did not immediately know it. By the end of the attack, the novel gas mixture had caused 1,069 casualties including 120 deaths.[103] Like chlorine, Germany had a large stockpile of phosgene as early as 1914 because phosgene was adopted in the 1880's for use in the manufacture of dyes. This ready made supply meant that Germany would not have to expend many resources in order to test and use the gas in combat.[104]

Though Germany was the first to possess and use phosgene, their introduction of the gas into battle that December would haunt them for the remainder of the war. The British had said shortly after the Second Battle of Ypres that they would not use any gas weapons that the Germans had not already used in combat; with Germany's use of phosgene in December, the Allies now had a sort of "permission" to use another poison gas in the war.[105] The French

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[101] The Allies claimed that their use of chlorine was completely justified on the grounds that Germany had already used it in combat. Jeffreys, 73.

[102] Freemantle, 127.

[103] Ibid, 128.
Phosgene was significantly more deadly than chlorine; moderate doses of the gas caused heart failure within 24 minutes and high concentrations could cause heart failure in minutes. Phosgene attacked proteins in the lungs, causing oxygen transfer to be disrupted, and fluid buildup in the lungs. Ibid, 127.

[104] Freemantle, 127.

[105] Marion Girard, *A Strange and Formidable Weapon British Responses to World War I Poison Gas* (Lincoln: University of Nebraska Press, 2008), 38.

initiated the Allied use of phosgene when they fired shells of the gas at the Battle of Verdun in February, 1916, using the mortars that the British had developed shortly after the Battle of Loos.[106] The British soon followed suit and first used phosgene in June of the same year, just before the Battle of the Somme, only a few months after their French allies.[107] Phosgene later became one of the main gases used by the Allies in World War I, while Germany reduced its use in favor of mustard gas. Though it was largely used only by the Allies, and was not the most heavily deployed gas in the war, phosgene resulted in the majority of gas related fatalities in World War I.[108] Verdun also marked the first use of a projectile based poisonous gas weapon, the first indisputable violation of the gas provisions within the Hague Convention by any of the major powers.[109] If Germany and the United Kingdom were able to stay within the bounds of the Hague Convention by technicality, after February the same could not be said for the French.

Shortly after the Second Battle of Ypres in April, the French chemist Victor Grignard began researching the synthesis of phosgene and quickly discovered how to create it on an industrial scale. Freemantle, 127.

[106] Coleman, 27.

[107] Freemantle, 128.

[108] The actual percentage of phosgene related fatalities to other wartime gases during the Great War is still an object of debate. One heavily cited estimate claims that more than 80% of the gas fatalities of World War I were caused by phosgene. The 80% statistic is derived from claims made by historian Augustin Prentiss of the American Chemical Warfare Service in a post war study. Unfortunately, Prentiss took great liberties when determining the percentage; his numbers were heavily inflated, but still resulted in only 74.9% of gas related fatalities, which Prentiss then rounded up to 80%. Historian Ludwig Haber, son of Fritz Haber, did estimate the number of gas related fatalities in the First World War, but he did not attempt to relate phosgene casualties to total gas related casualties because an accurate distinction between which gases caused which injuries would have been near impossible. T. Anthony. Ryan, *Phosgene and Related Carbonyl Halides* (Amsterdam: Elsevier, 1996), 35-39.

[109] Haber, *The Poisonous Cloud*, 34

Chapter 4: “Over There” - Isolationism in the Face of a World War

The Hague Conference and the War Overseas

On July 29, 1899, every major power in attendance at the First Hague Conference, except the United States, signed provisions limiting the use of chemical weapons in warfare.[110] The United States' representative for the conference was Naval Captain Alfred Thayer Mahan, who refused to sign the provisions on gas weapons on the grounds that he believed they might sometimes be humane to use.[111] Mahan was the only representative at The Hague Conference who declined to sign the gas provision, even though it was not very controversial and produced little debate when it was introduced.[112]

Thus, America was not obligated by international commitments against using chemical weapons in war, as all the major European powers in World War I were. Still, the United States performed very little research and had practically no interest in gas warfare before 1917.[113] The lack of pre-war research was likely caused by inadequate government funding and a relatively unspecialized industrial economy stemming from an isolationist foreign policy. In 1914, Army and Navy laboratories were underfunded and were only able to perform light tests on mundane equipment such as guns and cannons, leaving no room for investigations into chemical weapon

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[110] Scott, *The Hague Peace Conferences*, 231.

[111] Calvin Davis, *The United States and the First Hague Peace Conference* (Ithaca, NY: Cornell University Press, 1962), 119.

[112] Scott, *The Hague Peace Conferences of 1899 and 1907. A Series of Lectures*, 60-61.

[113] Joel A. Vilensky and Pandy R. Sinish, *Dew of Death: The Story of Lewisite, Americas World War I Weapon of Mass Destruction* (Bloomington, IN: Indiana University Press, 2005), 16.
As early as 1915, the US army assigned the Army Medical Service to try to work on respirators for gas and sent some observers to Europe, but no progress was made. In the same year in November, an Army War College study was done on the new state of warfare in Europe, and did not mention gas warfare.
Fredric Brown, *Chemical Warfare: A Study in Restraints* (Princeton, NJ: Princeton University Press, 1968), 19-20.
In the 1916 congressional hearings on the preparedness for national defence, Senator Beckham asked Colonel Treat if gas was being used, and the colonel replied "the papers say so, but we do not have any actual reports from our observers that they are using them" Ibid, 20.
The rest of the pre war experience can be seen in the following quote of Lieutenant Edgar Dow Gilman to the Reserve Officers Training corps in 1922. "No preparation whatever had been made during the two years that had passed since gas was introduced and our entry into the war. We had no masks or other protective devices, we did not know how they were made. Our soldiers had no gas training and there was no one in this country [U.S.] with sufficient knowledge or training to pass it on to them." Ibid, 21.

production and usage.[114] Similarly, U.S. corporations were far behind Europe, and specifically Germany, in terms of both chemistry and specialized manufacturing in 1914. Members of the American private sector would have faced major difficulties had any company endeavored to perform gas research.[115]

The German use of chlorine at Second Battle of Ypres was an incredibly controversial topic in Europe. Many countries criticized Germany for violating the Hague Convention, but the United States did not number among them. The event was reported in papers across America, but virtually no politicians or military leaders made any official statements about it.[116] The military silence about Ypres was not unexpected, since on August 16, 1914, just after the war began,

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[114] Daniel J. Kevles, *The Physicists*: The History of a Scientific Community in Modern America (Cambridge, MA: Harvard University Press, 1978), 103. Following the declaration of war, a military preparedness movement was formed, led by former President Roosevelt and former Chief of Staff of the United States Army Leonard Wood. William L. Genders, "WOODROW WILSON AND THE 'PREPAREDNESS TOUR' OF THE MIDWEST," *Australasian Journal of American Studies* 9, no. 1 (January/February 1990):. However, the preparedness movement was greatly opposed by President Wilson and by various women groups, churches, labor unions, and the Socialist party. Verity Burgmann and Jeffrey A. Johnson, "Workers against Warfare: The American and Australian Experiences before and during World War I," in *Frontiers of Labor: Comparative Histories of the United States and Australia* (Chicago, Illinois: University of Illinois Press, 2018). In a book written by Roosevelt published in January 1915, he harshly criticized Wilson explaining that he made "no allusion to the violation of the Hague conventions at Belgium's expense" Theodore Roosevelt, *America and the World War* (New York: Charles Scribner, 1915): x. and noting that Wilson was the "great official champion of unpreparedness in military and naval matters." Ibid, 184. The main cause of the lack of funding for research was likely the U.S. ideology of isolationism and anti-war preparation beliefs. By 1916, some American scientists who were interested in military research actually began to move to Europe to find better research opportunities, primarily in Britain. Kevles, 112-113.

[115] Germany's BASF had learned to synthesize ammonia from the nitrogen in the air, while other German companies were able to create precise equipment such as scientific instruments and specialized optics, none of which any American company could create. While the United Kingdom also did not have the means to produce ammonia from simple nitrogen, they were still able to create whatever munitions and fertilizers they required due to their dominance of the Chilean nitrate market. Ibid, 103.

[116] Information about the war coming in to the United States was generally first received through the War Department, where government officials would determine whether or not the information should go to the press. Frederick Palmer, *Newton D. Baker; America at War: Based on the Personal Papers of the Secretary of War in the World War* (New York: Dodd, Mead, 1931), 38. Scientific American released an article shortly after chlorine was used at Ypres which compared gas weapons to dumdum bullets. The article implied that the military use of gas weapons was still barbaric even though they were not used on civilians. Though the article was critical of the gas weapons, it did not mention that Germany in any negative light and attempted to stay away from the politics surrounding the use of gas. Arthur H. Compton, "Chlorine Gas on the Battlefield," *Scientific American* 115 (May 15, 1915):. The Boston Medical Journal also released an article about chlorine, though it prefaced its description as a chemical weapon with its use in water purification. The article mentioned that the Germans had used a gas which was assumed to be chlorine, but offered no condemnation of its use and sparingly mentioned anything related to

President Wilson had instructed the both the Secretary of War and Secretary of the Navy that they, and their subordinates, were not to issue any public statements about the war in Europe.[117] America was committed to remaining neutral in the war; not even gas usage on the other side of the ocean could arouse concern among many American minds—only an experience that brought the conflict directly into American experience could do that.

Weapons Under the Waves

On May 7, 1915, a German U-boat attacked and sank the *RMS Lusitania* in international waters. Germany claimed the Lusitania was carrying munitions and so its submarine sunk the ship without warning, killing approximately 1,200 people, including nearly 130 Americans.[118] Americans were outraged at the German Empire for the attack; many in the United States claimed that it was a violation of the Hague agreements because the ship was sunk without warning. Some Americans even alleged that the attack was premeditated by Germany.[119] The American Public did not seem very concerned about the fate of Europe while the effects of war occured overseas, but the sinking of the *Lusitania* symbolized American blood on German hands and many in the United States demanded action, though little came of such calls.[120]

Tensions escalated when on March 24, 1916, the German Empire sank the *SS Sussex*, a French ship carrying two Americans. The incident nearly caused the United States to sever diplomatic relations with Germany, but tensions eased when Germany restricted its submarine

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Germany. "THE DOUBLE WAR OF CHLORINE IN WAR," *The Boston Medical and Surgical Journal* 173 (July 1, 1915):.

[117] Palmer, 37.

[118] "Germany correctly contended the *Lusitania* carried illegal wartime contraband - including ten-and-a-half tons of rifle cartridges and 51 tons of shrapnel shells - Americans viewed the sinking of the *Lusitania* as murder." Andrew A. Wiest, *The Illustrated History of World War I* (London: Amber, 2014), 150. Willmott, claims the *Lusitania* "was not armed, carried no troops and the only munitions were 5,000 cases of cartridges and probably some explosive fuses." Hedley Paul Willmott, *World War I* (DK, 2003), 197.

[119] Willmott, *World War I*, 198.

[120] Willis J. Abbot, *The United States in the Great War* (New York: Leslie-Judge, 1920), 14.

warfare campaign with the Sussex Pledge.[121] Matters calmed between Germany and the United States until January 31, 1917, when Germany officially wrote to the United States that the German Empire would resume their campaign of unrestricted submarine warfare. President Wilson responded to Germany's statement by severing diplomatic ties between the United States and Germany on February 3, 1917.[122]

The final straw for the United States came when government officials learned about the Zimmerman Telegram to Mexico. The secret German diplomatic communication was intercepted and decoded by British Intelligence and then forwarded to the United States. The telegram indicated that a war with the United States was not Germany's intention, and that the empire would do its best to keep America neutral in the war. The telegram went further to say, however, that if a war with the United States could not be avoided, Germany would help Mexico regain their lost territories from the treaty of 1848 if Mexico declared war against the United States.[123] The United States then sent a letter to the American embassy in Mexico, requesting the Zimmerman Telegram be disclosed to Mexican General Venustiano Carranza.[124] Further, the American Ambassador to Mexico was told to mention to Carranza "[I]t is probable that the contents of this note will be made public in the United States immediately . . . it might be well for the Mexican Government to make some comment."[125]

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[121] Germany promised to not torpedo unarmed merchant ships at all, other vessels destroyed after due warning and removal of passengers and crew. Willis J. Abbot, *The Nations at War* (New York: Leslie, 1918), 151.
[122] *Congressional Record: Proceedings and Debates of the Sixty-Fifth Congress* (Washington: Government Printing Office, 1917), 1917.
[123] "Zimmermann Telegram," Robert Lansing to Walter Page, February 24, 1917, General Records of the Department of State.
[124] Venustiano Carranza was the First Chief of the Constitutionalist Army of Mexico, essentially the head of the executive power in Mexico at the time America sent its letter on February 26, 1917. He would later be sworn in as Mexican President on May 1, 1917.
[125] "Telegram from Frank Polk to the American Embassy in Mexico City," Frank Frank Polk to American Embassy in Mexico City, February 26, 1917, General Records of the Department of State.

Declaration of War and American Readiness

> I advise that the Congress declare the recent course of the Imperial German government to be in fact nothing less than war against the government and people of the United States; that it formally accept the status of belligerent which has thus been thrust upon it; and that it take immediate steps, not only to put the country in a more thorough state of defense but also to exert all its power and employ all its resources to bring the government of the German Empire to terms and end the war.
>
> - President Woodrow Wilson, April 2, 1917[126]

The official declaration of war by the United States to Germany came on April 6, 1917, four days after President Wilson gave his recommendation to Congress, and only about five months after Wilson won reelection with the slogan "He kept us out of the war." Though America had not shown great personal interest in the war while it remained strictly overseas, Germany's submarine warfare campaign allowed the conflict to leach out of Europe until its effects on America were too great to ignore. Wilson described the German government as one "which has thrown aside all considerations of humanity and of right . . ." while claiming that Americans were friends of the German people and the United States only sought the downfall of a government "that did what it pleased and told its people nothing."[127] Wilson stated that the entry of the United States into the war was purely a selfless action; that America would seek no compensation, as its only purpose in the war was for the world to "be made safe for democracy"

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[126] *Congressional Record: Proceedings and Debates of the Sixty-Fifth Congress* (Washington: Government Printing Office, 1917), 1117.
[127] Ibid.

in the face of "autocratic governments backed by organized force which is controlled wholly by their will, not by the will of their people."[128]

The United States had one main advantage upon its entry into the war; the country was not yet exhausted from the conflict that had been ravaging the European landscape for the past three years. Unfortunately for the United States, its military was entirely unprepared for its entry into the Great War "over there," having only carried out light preparations a few months before the declaration of war.[129] Prior to America's entry into the war, the United States military had yet to develop even a single gas mask, placing America far behind the European powers in its ability to use and defend against modern weapons.[130]

Although the United States lagged far behind Europe in terms of gas technologies, the American research method was not starting from nothing. The United States Bureau of Mines had been assigned the preliminary responsibility for handling the United States' chemical warfare in February, 1917, as the bureau had previous experience from research and development of gas masks for use in mining in 1908.[131] The Bureau of Mines had not actually done anything related specifically to chemical warfare before the conflict reached the America, so the United States Council of National Defense formed a Committee on Noxious Gases. On April 6, 1917, the very same day Congress declared war on Germany, the committee began its research into gas warfare by studying British and French gas literature.[132] By the end of July,

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[128] Ibid.

[129] "Over There" was a popular American song written in 1917 about American troops traveling to Europe to battle "the Hun." It was not until the events surrounding the sinking of the *Sussex* that Wilson signed the National Defense Act of 1916 to increase the size of the National Guard and called for the creation of the National Research Council to organize all available resources and scientists in the case of the outbreak of war.

[130] Amos A. Fries and Clarence J. West, *Chemical Warfare* (New York: McGraw-Hill Book, 1921), 32.

[131] The Bureau of Mines had been put in charge of chemical warfare before the declaration of war in case the United States was drawn into the conflict, and it focused solely on defenses against gas attacks. Fries, 33.

[132] Charles E. Heller, "Chemical Warfare in World War 1: The American Experience, 1917-1918 (Leavenworth Papers, Number 10)," September 1984, 38, doi:10.21236/ada189331.

1917, America had manufactured approximately 20,000 gas masks, all of which were based on British designs.[133]

Though the Bureau of Mines focused primarily on defenses against gas warfare, Americans also investigated the offensive use of gas. Defensive gas research primarily came out of university chemical laboratories, and the two main universities at which the United States chose to carry out its chemical research were the Catholic University of America in March, 1917, and American University in April, 1917. While the two universities were not the only ones to perform research, they were the best situated due to their location in Washington D.C., their relatively advanced laboratories, and their willingness to help in the war effort.[134] By May, 1917, the Bureau of Mines had access to 21 universities and their laboratories to help with research, along with 15,000 chemists who indicated they would be willing to help in the research of chemical weapons in a national survey.[135]

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[133] Fries, 50.

[134] Fries, 50. Catholic University of America was enthusiastic about helping in the war effort. Rector Thomas Shahan stated in his letter to Wilson, "In view of the present emergency the Catholic University of America has the honor to offer itself to you for such services as the Government of the United States may desire from it." to which Wilson responded, "Let me thank you warmly for your generous letter of March 28. I am very grateful to you for your pledge of cooperation and support." The university had no trouble finding support from its students, with the school administration telling them on May 26, 1917, "This war itself is a scientific war; and before it ends we shall need, as other nations have already found, to continue unremittingly at the task of research and preparation." Joel A. Vilensky and Pandy R. Sinish, *Dew of Death: The Story of Lewisite, Americas World War I Weapon of Mass Destruction* (Bloomington, IN: Indiana University Press, 2005), 17.

[135] Ibid, 16.

Chapter 5: A King is Born - Mustard Gas on the Western Front

Blisters and Blindness

On June 26, 1917, at St. Nazaire in France, the first American soldiers landed in Europe and exited their ships to the sounds of cheering as French citizens gathered in crowds to show their support for America's entry into the war. By 1917, France had been battered by World War I; its military was exhausted, its countryside was pockmarked with artillery craters, and the majority of its territory northeast of Paris was still occupied by German forces. America's declaration of war signaled to the French and British that relief was soon on its way, but the small number of troops in that first wave would not be enough to give France or Britain any real sense of reprieve. By the time Americans entered the war on any significant scale, French and British troops would have already spent years under constant bombardment by the Germans. In July, Germany's chemical weapon developers unleashed what would become the "king of the battle gases": dichlorodiethyl sulfide, more commonly known as mustard gas.[136]

Mustard gas was not a new chemical so much as it was a new weapon. The pungent yellow-brown gas was first synthesised in an impure state in Germany, and appeared in scientific literature as early as 1860.[137] By 1886, German chemist Victor Meyer had synthesised mustard gas in its pure state and wrote about its various harmful effects in detail.[138] In 1912, Hans Thacher Clarke, an English chemist studying in Germany, worked with Meyer to devise a better method of producing fairly pure mustard gas that was safer and easier to use than the one Meyer had devised 26 years prior.[139]

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[136] Amos Alfred Fries and Clarence Jay. West, *Chemical Warfare* (New York: McGraw-Hill, 1921), 150.
[137] Frederick Gurthie, "On Some Derivatives from the Olefines," *Quarterly Journal of the Chemical Society* 12 (1860): 109-120; as cited in Haber, *The Poisonous Cloud*, 342.
[138] Curt Wachtel, *Chemical Warfare* (Brooklyn, NY: Chemical Publishing, 1941), 221.
The blistering effect of mustard gas was known in 1860, but Meyer was the first to write about the damage to the lungs that it also causes. Haber, *The Poisonous Cloud*, 342.
[139] Ibid, 343.

Despite this basis in established knowledge, research on mustard gas took a back seat to chlorine early in the war, and so it was only introduced in the final months of 1917. Fritz Haber had considered multiple gases, including mustard gas, as contenders for use at Ypres near the beginning of the war, but he settled on using chlorine because of its high toxicity and availability.[140] Haber specifically rejected mustard gas because he did not believe its toxicity was great enough.[141] In the modern day, chemical weapons are divided into several subcategories: weapons like chlorine and phosgene are known as pulmonary or choking agents, benzyl bromide and xylyl bromide would be classed as lachrymators or as lachrymatory agents, and mustard gas would be categorized as a vesicant or a blistering agent. Haber focused on the toxicity of mustard gas, which is fairly low compared to many other chemical weapons, but ignored the debilitating and horribly painful blisters that resulted from mustard gas exposure.

In 1916, two German scientists who had previously worked with Fritz Haber, Wilhelm Steinkopf and Wilhelm Lommel, again proposed the use of mustard gas in war. Laboratory studies on the gas in September, 1916, indicated it would fare well in battle, and in the spring of 1917, Germany began filling a small number of shells at a factory in Adlershof, near Berlin.[142] Shortly after the shell filling began, an accident at Adlershof caused the station to explode, destroying all the equipment and gas shells it had manufactured.[143] After the explosion, many German gas experts were hesitant to use mustard gas, not only because of the explosion, but because German gas masks were not effective against it.[144] Though the factory explosion clearly displayed the hazards of the chemical, it also showed the clear potential mustard gas had as a

[140] Ibid, 117.
[141] Ibid.
[142] Wachtel, 221.
[143] Ibid, 221.
[144] Ibid, 222.

weapon. Despite the incident, testing on mustard gas continued, and by July, 1917, Germany had enough shells to fire 50,000 of them at Ypres.[145]

Shortly before the Battle of Passchendaele, also known as the Third Battle of Ypres, Germany fired mustard gas shells at British forces for the first time in the war.[146] Germany hoped that the gas shells would delay the British, who appeared to be gearing up for a major offensive.[147] The shelling continued for about two weeks before the full scale battle commenced on July 31, 1917, but Germany stopped using the gas during the battle, both due to a supply shortage and because the military was unsure of how effective the gas had actually been.[148] Once again, German scientists did not seem to understand the military significance of the gas, but the consequence of their misunderstanding was not as severe as those created by their blunder with chlorine two years prior. At the Second Battle of Ypres, Germany had intended to use chlorine offensively to create a breakthrough in the trenches, but the stakes were much lower for mustard gas at Passchendaele because the gas was used defensively.[149]

German forces at Passchendaele used mustard gas because it had a much longer half life than other gases, and its relatively high density compared to air meant the gas would persist on the battlefield and linger in the trenches.[150] Like Haber, the German forces at Passchendaele did

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[145] Haber, *The Poisonous Cloud*, 192.
[146] Ibid.
[147] Lyn MacDonald, *They Called It Passchendaele* (London: Penguin, 1979) 65. At the end of June, 1917, the First Sea Lord Admiral John Jellicoe claimed, "There is no good discussing plans for next spring - we cannot go on." Due to high shipping losses, Jellicoe believed that unless, the ports of Ostend and Zeebrugge on the Belgian coast were captured, Britain would be forced to withdraw from the war, even though most of the submarines operated out of German not Belgian ports. Soon after Jellicoe's statement, large numbers of soldiers and armaments poured into the rear lines around the Ypres Salient to prepare for an offensive. German intelligence observed the mounting Allied forces, and inferred the next attack almost certainly was going to be in Flanders. MacDonald, 65-67.
[148] Ibid, 193.
[149] Wachtel, 223. German mustard gas attacks were continued throughout the war until July, 1918. Diminishing mustard gas attacks after July led the Allies to assume there was a shortage of the gas on the German side. This is not entirely true as the Germans planned a general offensive on the Western Front in the spring and summer of 1918. As a result, the Germans were supplied with offensive gases, not defensive gases like mustard gas.
[150] Haber, *The Poisonous Cloud*, 193. According to the American Expeditionary Forces, on the open battlefield, mustard gas was expected to last for about 24 hours in open ground. If the area was heavily forested, it could last

not realize the gas wounded through skin contact, meaning gas masks might have offered slight protection to the lungs and eyes, but did little to protect the body. In terms of skin contact, soldiers also had very little protection; mustard gas is able to diffuse through clothing; a standard uniform did little to prevent the blistering that caused 90% of mustard gas casualties.[151]

After the initial shelling at Passchendaele, the British military attempted to hide the casualties associated with the vesicant from Germany, hoping that they would not realize the demoralizing effect the gas had on British troops.[152] Still, Germany was able to learn about the effects of the gas through Allied prisoners of war that were affected by it, and by December, 1917, Germany had created another stockpile of mustard gas shells.[153] From December, 1917, to March, 1918, Germany intentionally used mustard gas sparingly—not because of a misunderstanding of the effects of the gas, but because the German military was learning how to best utilize it.[154] When Germany began regularly using mustard gas, they deployed it differently from the other battle gases. Instead of using mustard gas during battle, German forces would launch shells of the gas before their attack, giving time for the gas to dissipate before it could affect German troops while also causing early casualties to the Allies.[155] From March until June,

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anywhere from 7-10 days. Phosgene, in contrast, was expected to last for about 20 minutes in open ground and 3 hours in the woods. Freemantle, 134. Mustard gas was a particular problem because it not only contaminated the area but could also recontaminate soldiers and horses if the gas was disturbed. Cecil Withers, a British soldier, remembered being exposed to mustard gas during a mortar attack: "I suffer[ed] badly from phlegm and from coughs and colds a lot. That all started when the British were shelling hard at the last Battle of the Somme. One of the shells disturbed the residue of mustard gas that had been lying there for months . . . I got secondary gas." Fitzgerald, G. J. "Chemical Warfare and Medical Response During World War I." *American Journal of Public Health* 98, no. 4 (2008): 622. doi:10.2105/ajph.2007.11930.

[151] Freemantle, 133; Ibid, 134. This was according to George Burrell, who headed the Research Division of the Chemical Warfare Service in the United States.

[152] Cunningham, D.J.C:'C.G. Douglas,' Obit FRS, NS10(1964), p.59. (as cited by Haber, *The Poisonous Cloud*, 195.)

[153] Haber, *The Poisonous Cloud*, 193.

[154] Ibid.

[155] Fries, 176.

Germany began regularly incorporating shells of mustard gas into its chemical arsenal, but by June's end, Germany was no longer the only power able to develop and use mustard gas.

Allies Crack the Final Gas

The Allies started using mustard gas late in the war because it took significantly longer for them to learn how to mass produce the gas than it took Germany. When Germany first used the gas in July, 1917, Allied chemists immediately recognized the chemical as dichlorodiethyl sulfide, but the Allies did not yet have a good way of producing the gas.[156]

While Germany had little trouble producing mustard gas using the method developed in 1912 by Clarke and Meyer, British and French chemists were unable to reproduce their results, and instead were forced to rely on the more difficult and dangerous method developed by Meyer in 1886.[157] By the end of August, 1917, Allied chemists had produced only a miniscule amount of mustard gas, and even worse, the process required use of ethylene chlorohydrin as an intermediate, another dangerous chemical even harder to procure in the Allies' chemical stockpile.[158] In September, chemists in the United States began working to create mustard gas, but they too suffered the same failures that their allies in Europe had experienced.[159] Between August and December, the Allied chemists made little progress towards producing mustard gas, however, in January, 1918, a British chemist named William Jackson Pope suggested substituting the ethylene chlorohydrin with sulphur dichloride, which would help solve the supply issue.[160] That same month, France and Britain enlisted more chemists to work on the

[156] Haber, *The Poisonous Cloud*, 111.
[157] Ibid, 112.
[158] Ibid, 111.
[159] Ibid, 113.
[160] Ibid, 112.

synthesis of mustard gas, and by April, France, Britain, and the United States were able to reliably generate the compound, though they all experienced extremely low yields.[161] A breakthrough finally came when French chemists discovered that the yield could be improved by reducing the temperature of the reaction. By the end of April, France was able to produce the first reliable and efficient synthesis of Allied mustard gas. About a month later, in May, Britain and the United States were also manufacturing substantial quantities of mustard gas.[162]

The French were the first of the Allies to use mustard gas in battle when they fired shells at German forces on June 16, 1918.[163] The British were second to use the gas, but did so about 3 months later, on September 18, the opening day of the Battle of St. Quentin Canal near Bellicourt in France.[164] Germany's chemical superiority allowed them to first use the gas July, 1917, about 11 months before any Allied power could respond in kind, but scientific prowess alone cannot win a war.

In October, 1917, the Bolshevik Revolution forced Russia to end the fighting on the Eastern Front, seemingly giving Germany one last chance to defeat the British and French before the Americans could arrive in full force. Germany launched its final offensive in Spring, 1918, but their last-ditch effort was repulsed by the Allied forces. Soon, American troops arrived en masse in Europe, and an Allied counter offensive began pushing the Germans out of France and Belgium. Fearing that the fighting could reach German territory, Germany was forced to seek an armistice and an end to the war.

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[161] Ibid.
[162] Ibid, 113.
[163] Freemantle, 132. The date that the United States first used mustard gas is difficult to find, but the first shells that the United States used were given to them by France, since France was the first of the Allied powers to produce mustard gas efficiently.
[164] Ibid, 132-133.

Chapter 6: The Price of Peace - Reparations and the Shadow of Chemistry

No Rest for the Wicked

The armistice was signed on November 11, 1918, at 5:00 AM in France, and was scheduled to go into effect at 11:00 AM that same day. An hour before noon, the entire Western front fell nearly silent, save the sounds of birds singing in no man's land.[165] While some soldiers rejoiced at the end of the fighting, others were too damaged by the war to feel any real sense of joy from the announcement. Clifford Lane, a British Corporal in the 1st Battalion, Hertfordshire Regiment, recounted in a post war interview:

> Then as far as the armistice itself was concerned, it was an anti-climax. We were too far gone, too exhausted, really to enjoy it. All we could do was just go back to our billets; there was no cheering, no singing, we had no alcohol – that particular day we had no alcohol at all – and we simply celebrated the armistice in silence and thankfulness that it was all over. And I believe that happened quite a lot in France.[166]

Though the armistice ended the fighting, the war did not technically end until the peace treaty was signed in 1919.

The Treaty of Versailles, signed on June 28, 1919, exactly five years after the assassination of Franz Ferdinand, marked the official end of World War I.[167] The treaty imposed extremely harsh conditions upon Germany, and demanded that the defeated state accept both moral and financial responsibility for the conflict. Further, the treaty stripped Germany of its colonies, mandated a reduction in size of its military, and forced Germany to cede portions of its

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[165] Some sources indicate that the sounds of gunshots and explosions were replaced by birds chirping. The bird chirps could be heard throughout the war, which helped inspire some of the lyrics in the poem *In Flanders Fields*. John McCrae, *In Flanders Fields* (Ottawa: Union Government Publicity Bureau, 1917). The last casualty of the war was an American named Henry Gunther, who died at 10:59 AM, a minute before the fighting ceased. Gunther was killed while trying to capture a German machine gun nest by himself. For their part, the Germans had pleaded with Gunther to turn back, telling him that the war was almost over, but were forced to kill him after Gunter continued to fire his weapon at them. Gunter had recently been demoted, and his comrades reported that he might have rushed the German machine gun in an attempt to redeem himself just before the war's end. Paul Kendall, *Armistice 1918: The Last Days of The First World War Told Through Newspaper Reports, Official Documents and the Accounts of Those Who Were There* (Barnsley: Frontline Books, 2017).

[166] Max Arthur, *Forgotten Voices of the Great War* (London: Ebury, 2014), 311.

[167] The United States did not ratify the Treaty of Versailles, as Congressional isolationists refused to join the League of Nations. Ironically, the idea of the League of Nations had been first proposed by President Wilson.

own national territory to France and the newly reformed Poland.[168] With respect to chemical weapons, the treaty also banned the use, manufacture, and importation of "asphyxiating, poisonous or other gases and all analogous liquids, materials or devices" specifically in Germany.[169] Britain further proposed an amendment that, in order to ensure German compliance, the Allies should take "effective possession of all chemical processes including drawings of plants, manufacturing instructions, and reports of research to date used during the war or for the production of substances from which such things were or can be made."[170] Woodrow Wilson believed the British amendment was both impossible to enforce, as the Allies would have no way of knowing if they were given everything Germany had, and he also suspected that the proposal had underlying economic motives. Due to American opposition, the amendment did not become part of the treaty.[171]

A Relative "Peace" and the Future of Gas

The economic burden of waging a war in itself can be difficult to manage, but Germany's situation became even worse after the fighting ended due to the Treaty of Versailles. The financial burden on Germany became impossible to manage, and the early 1920's saw the extreme hyperinflation of German currency, and the complete economic destruction of the Weimar Republic, culminating in Germany missing two reparation payments by the end of

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[168] Attendees of the Treaty of Versailles, *Treaty of Peace between the Allied and Associated Powers and Germany. Versailles* (1919). Article 119 (required Germany to renounce sovereignty over former colonies); Article 163 (The German army could not exceed 200,000 men three months after the treaty went into effect, and was not to exceed 100,000 men after March 31, 1920); Article 181 (the navy could no longer have more than 6 battleships); Article 198 (military use of airplanes was forbidden altogether); Part III, Section V (lands to France); Part III, Section VIII (lands to Poland);

[169] Ibid, Article 171.

[170] US Department of State, *Papers Relating to the Foreign Relations of the United States: 1919: The Paris Peace Conference*, vol. IV (Washington: Department of State Printing Office, 1942), 560.

[171] Ibid, 561.

1922.[172] France reacted to the missing payments by sending troops into the Ruhr region of Germany in early 1923, an act which provoked the suspension of all reparation payments and a campaign of passive resistance against the French.[173] All German chemical factories on the Rhine defiantly ceased production, inducing French troops to seize and pillage the factories.[174] Carl Bosch was given enough of a warning about the French takeover that he was able to transport most of his equipment out of the BASF plants at Oppau and Ludwigshafen and flee to Heidelberg in unoccupied Germany. Carl Bosch was tried in absentia by the French for impeding the delivery of reparation goods, and he was sentenced to 8 years in prison and fined 150 million marks, though he never actually faced those consequences.[175]

Though Europe was not completely at peace even after the Treaty of Versailles, with relations tense specifically between France and Germany, the continent appeared to be aligning on the specific issue of gas weapons. While Europe was still recuperating from the war, the League of Nations began an international dialogue on the use of chemical weapons. In May, 1920, a British representative to the League of Nations suggested that the world should have an in depth discussion about the use of chemical weapons in warfare. The representative sent out a sort of survey to the other members of the League of Nations, asking four main questions, which in essence were: (1) is the use of gas cruel, (2) should the use of gas be limited in the same way as conventional weapons, (3) is it possible to limit the use of gas, for instance requiring laboratories to report any new chemicals that could be used as weapons, and (4) should this topic continue to be discussed within the League of Nations?[176] Most countries seemed to be in

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[172] Jeffreys, 114.
[173] Ibid.
[174] Ibid, 115
[175] Ibid.
[176] Paul Elek, *The Problem of Chemical and Biological Warfare*, vol. 4 (Stockholm: SIPRI, 1973), 43.

agreement that chemical weapons were cruel and should be limited, and agreed that the topic should be discussed more in depth, but did not necessarily agree that researchers should be required to openly disclose their research on gases.[177]

On February 6, 1922, as part of the Conference on the Limitation of Armaments held in Washington D.C., representatives from the United States, France, Italy, Japan, and the United Kingdom, the victors of World War I, began to negotiate a treaty barring the use of chemical weapons. Article V of the treaty prohibited "The use in war of asphyxiating, poisonous or other gases, and all the analogous liquids, materials or devices, having been justly condemned by the general opinion of the civilized world and . . . in the Treaties to which a majority of the civilized powers are parties," though the article was not adopted because France had disagreements with it.[178] Still, the article was brought up later that year at an assembly of the League of Nations, and discussion continued on the topic.[179]

In September, 1922, a four-member commission was set up to study the development of chemical weapons, and in 1924 released a report written by prominent chemists, biologists, and physiologists that discussed the effects of chemical and biological weapons. The report covered the effect of the controversial weapons on the environment, the chronic health effects on soldiers, and the difficulty in defending against the weapons. Overall, the report advocated for the regulation and suppression of both biological and chemical weapons.[180]

In 1925, representatives of many countries around the world arrived at Geneva to draft a document related specifically to the use of chemical weapons in war. The Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological

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[177] Elek, 44.
[178] Elek, 46.
[179] Elek, 47.
[180] Elek, 49-55.

Methods of Warfare, which is usually simplified to the Geneva Protocol, was drafted on June 17, 1925.[181] The document was also signed on the same day by 38 countries, including France, Britain, the United States, and Germany.[182] The Geneva Protocol was designed to prohibit the deployment of chemical weapons against other signatories of the protocol, but it did permit the use of chemical weapons in response to an enemy chemical weapon attack, and it also allowed for the use of gas on countries that had not signed the protocol. Moreover, the protocol did nothing to prevent the manufacture and stockpiling of chemical weapons, it only prohibited the use of those weapons on fellow signatories.[183]

Even though the Geneva Protocol banned the use of chemical weapons between signatories, poison gas research and development continued through the interwar period and into World War II. Lewisite, an American designed chemical weapon completed near the tail end of 1918, that was both poisonous and a vesicant, continued to be tested and developed until 1940, when Britain unveiled it had created an antidote for the toxin.[184] The British Anti-Lewisite, sometimes shortened to BAL, and today known as dimercaprol, did not defeat the vesicant effects of lewisite, but did negate its toxicity.[185] The BAL essentially obsoleted lewisite before it could ever be used in combat, and turned the world's attention back to mustard gas. Mustard gas itself continued to be researched and perfected during World War II, even though the weapon was never used in the conflict.[186]

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[181] Elek, 69. By 1924, more countries were beginning to fear the development and use of biological weapons, so the 1925 Geneva Protocol was created with the intent of limiting both chemical and biological warfare at the suggestion of the recently reformed Poland. Ibid, 57; Ibid, 60.
[182] France, the United Kingdom, and the United States all signed the document with specific reservations, Germany signed the document with no reservations. Ibid, 342.
[183] Ibid, 69-70.
[184] Vilensky and Sinish, 51; Ibid, 79.
[185] Ibid.
[186] Susan L. Smith, *Toxic Exposures: Mustard Gas and the Health Consequences of World War II in the United States* (New Brunswick, N.J., 2017), 21.

Overview of Gas Warfare

By the end of the war, some 125,000 tons of gas had been deployed in battles by both the Allied and Central powers. Of that total 125,000 tons, about 100,000 tons (~80%) were pulmonary agents, such as chlorine and phosgene, and 12,000 tons (less than 10%) were vesicants. Of the nearly 1.3 million casualties, however, pulmonary agents caused about 875,000 casualties, while the vesicants, which primarily consisted of mustard gas, resulted disproportionately in about 400,000 casualties—nearly 33% of the total casualties. In terms of material efficiency, pulmonary agents caused about 1 casualty per 230 pounds of gas, while vesicants caused about 1 casualty per 60 pounds of gas.[187]

After Germany had unleashed its mustard gas against the Allies, the British and French militaries sought protective gear that would work against the vesicant. The French had managed to design and manufacture some simple protective clothing, which they primarily gave to their artillery units, but the British were not impressed by the garments. The British chemical advisors did not believe that the severity of injuries obtained at the front from mustard gas warranted the purchase or production of protective clothing, and a Canadian chemical advisor even noted that some soldiers were purposely exposing their eyes to mustard gas in order to gain some rest in a hospital.[188] Though mustard gas did cause a fair number of injuries relative to pulmonary agents, most of the injuries were minor enough that the soldier would be back to the front fairly soon, usually within 46 days.[189] In terms of other gases, virtually all of the pulmonary agents used

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[187] Augustin M. Prentiss and George J. B. Fisher, *Chemicals in War: A Treatise on Chemical Warfare* (New York: McGraw-Hill Book, 1937), 662. Considering that mustard gas is also more dense than chlorine or phosgene, the discrepancy in effectiveness between pulmonary agents and vesicants is likely even larger when the volume of gas per casualty is considered.

[188] Jones and Richard Hook, *World War I Gas Warfare Tactics and Equipment* (Oxford: Osprey Publishing, 2008), 49-50. Haber actually made the assurance that mustard gas exposure did not usually result in permanent blindness. Jones and Hook, 55.

[189] Joy, "Historical Aspects of Medical Defense," 101. Fitzgerald, 611-625.

during the war could be blocked by gas masks. By the late stages of the conflict the gases actually became more of a nuisance than a threat because the gas masks were effective, but very uncomfortable to wear and difficult to see through.[190] One soldier recalled a gas attack in a post-war interview, claiming "it took me all of my willpower not to pull off my mask," even though he understood the risk of major injury or death had he removed the respirator.[191]

Unfortunately, while soldiers usually had the proper protective equipment to negate the effects of gases, this was not true for civilians. When mustard gas entered the Great War, it did not cause many fatalities among soldiers, but killed a fair number of civilians. On the night joining July 20 and 21, 1917, Germans at Armentières shelled Allied forces with mustard gas, but accidentally injured 675 civilians living nearby, of whom 86 were killed.[192] Mustard gas in particular was able to settle into the cellars of many houses near battlefields, and considering mustard gas could last as long as 2 weeks in a forest, it likely was able to last much longer in a low, enclosed basements.[193]

Even though World War II was larger in scale than World War I, none of the military combatants used chemical weapons in any of the battlefield situations. Because Hitler had been gassed in 1918, he retained a strong personal aversion to the weapon on the battlefield.[194] On the American side, General George Marshall expressed his opposition to the use of chemical weapons against the Japanese because, even though the weapons might have been effective during the island hopping campaign, he feared using the weapons would give the Germans an

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[190] Ellwood B. Spear, "Some Problems of Gas Warfare," *The Scientific Monthly* 8, no. 3 (1919): 277.
[191] Haber, *The Poisonous Cloud*, 204. If a soldier did remove his mask to phosgene, but did not die from the exposure, the average time he would be out of the war was 46 days, the same amount of time for mustard gas.
[192] Jones, 49.
[193] Haber, *The Poisonous Cloud*, 193.
[194] Ibid, 205.

excuse to use them as well. Marshall asked others to remember the soldiers of World War I, who in the "cold and mud, under shell and machine gun fire, [were] bombed and gassed."[195]

Chemical weapons did see some sparse use during the interwar period in the 1930's, especially against civilians. Fascist Italy had used mustard gas in 1935 and 1936 during the Second Italo-Abyssinian war with Ethiopia. Both the civilian and military forces were unprepared for the vesicant, and by the end of the war, one Soviet estimate showed 15,000 of the 50,000 Ethiopian casualties were caused by chemical weapons.[196] When Japan used chemical weapons against China in the mid 1930's, they defended its use by claiming that China was not an advanced civilization, and since Japan had not signed the Geneva Protocol, it should not have mattered whether the Chinese were killed by gas or by bullet.[197] In both the cases of Japan and Italy, chemical weapons were used against people who had no defenses against it—essentially, decision makers had concluded that the weapon could only ever be used effectively against an already militarily inferior opponent.

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[195] Thomas M. Dolan, "Unthinkable and Tragic: The Psychology of Weapons Taboos in War," *International Organization* 67, no. 01 (2013): 48-52.

[196] Lina Grip and John Hart, *SIPRI Arms Control and Non-proliferation Programmme* (Stolkholm, SIPRI, 2009), 1-3.
The League of Nations investigated the use of gas, given that Ethiopia and Italy had both signed the Geneva Protocol in 1925. Italy justified their use of chemical weapons by claiming that Ethiopia had already committed war crimes by using dumdum bullets and had already attacked noncombatants. The League of Nations ultimately decided to punish Italy only by restricting its ability to import chemical weapons.Elek, vol. 4 ,187.

[197] Richard M. Price, *The Chemical Weapons Taboo* (Ithaca, NY: Cornell Paperbacks, 2007), 112.

Chapter 7: Science and Philosophy - A Retrospective on the War

Just War: Successes and Failures

This paper began by framing the topic of chemical weapon usage during World War I within scope of Just War theories as they were understood at the time. Three perspectives were deliberately picked to be irreconcilable with each other; Tolstoy's pacifism was essentially the opposite of Clausewitzian *kriegsraison*, and Lieber's philosophy lay in the middle ground between the two. The obvious question posed by this framing is: which interpretation would prevail? Unfortunately, the answer to that question is not as simple as the question itself.

Leo Tolstoy, even before the conference was held, stated his belief that the First Hague Convention was already a failure. Tolstoy believed even the act of banning a weapon defeated its own purpose, as there would be no reason to ban a weapon nobody expected to be used. Tolstoy saw the Hague Conference would fail in its goals long before its provisions were broken during World War I, yet his ideology of pacifism was unrealistic. Tolstoy did not believe a war could be just, and so his ideology fails spectacularly to describe the military behavior of any power in World War I, or really in any war.

Understanding the inapplicability of Tolstoy's views within early 20th century European geopolitics, *kriegsraison* might seem a more viable alternative to understanding the conflict from a militaristic point of view. Germany skirted the bounds of the Hague Conventions by releasing chlorine in 1915, and by the end of the war, every major power had clearly violated the peace conferences they had signed just decades prior. *Kriegsraison* might also explain why Germany invaded neutral Belgium, yet it fails to explain why Germany chose to release its initial gases from canisters. Rather than simply firing the gases as projectiles, Germany attempted to remain within the technical bounds of the Hague Conference, yet *kriegsraison* would dictate any adherence to a treaty should always come second to a potential military advantage.

Lieber's philosophy provided a middle ground between *kriegsraison* and pacifism, yet still does not effectively model the decisions made by each power in World War I. Lieber believed a war could be fought justly, so long as certain, prearranged restrictions were upheld by the combatants. The harsh treatment of Germany under the Treaty of Versailles supports Lieber's theory, as Germany most often violated the agreed upon rules of war first, but that does not mean they always violated them first. France, for instance, used tear gases in the Great War before any other power and, at the Battle of Verdun, became the first power to launch poison gas projectiles during the war. By the end of the war, each power had violated the Hague Conventions, yet none of the Allies faced scrutiny for their infractions.

Neither side of the conflict conformed to any consistent concept of Just War theory in World War I, despite the volume of rhetoric provided by both the Allies and the Central Powers in regards to the other's conduct of the war. Though France and Britain were quick to argue the illegality of chlorine usage under the Hague Convention, Britain developed a mortar capable of launching gas shells, and France used that mortar to fire gas shells in the first unequivocal and direct violation of the gas provisions within the Hague Conventions. Meanwhile, Germany attempted to remain within the technical bounds of the Hague Conventions by initially only releasing chlorine and phosgene from canisters, yet continued to introduce numerous gases into the conflict after Allied leaders claimed any poison gas use was illegal under that very agreement. The leaders of each nation in the Great War made decisions based on the nuances of each issue, and those nuances would be impossible to capture within the framework of a single Just War doctrine.

The Legacy of Chemical Weapons

The War to End All Wars would be widely recognized as an ironic misnomer within two decades, but with respect to major powers' uses of poison gases on battlefields, World War I really was a unique event. Since the signing of the armistice, no major power has used chemical weapons against any other major power in war, including through all of World War II. Chemical weapons are now classed alongside nuclear and biological weapons as weapons of mass destruction, or WMDs, yet their scope and destructive capabilities pale by comparison with either biological or nuclear arms.

Compared to chemical weapons, machine guns might have seemed, at the outset, more inhumane than poison gas. Though machine guns were generally regarded as more effective in combat than chemical weapons, they were also easier to control and had a much lower propensity for harming unintentional targets such as civilians. For instance, in 1917, Germany proved unable to control its mustard gas attack at Armentières when the gas drifted from the battlefield and into a nearby town, accidentally causing hundreds of civilian casualties. In essence, poison gases are indiscriminate weapons that target both civilians and soldiers alike, while machine guns must be deliberately targeted at civilians for them to be affected. For these reasons, high-speed projectile weapons such as machine guns have been adopted by military powers around the world and remain a staple of modern warfare even to the present day, owing to their effectiveness and controllability, while chemical weapons usually possess neither attribute.

Chemical weapons on a broad scale are virtually useless against modern gas masks, and therefore useless against any opponent who is able to outfit soldiers with the proper equipment. In World War I, the gases proved difficult to control, with Germany being forced to wait until

the wind was in their favor to release chlorine at the Second Battle of Ypres. German Commander Rupprecht, Crowned Prince of Bavaria, noted after Ypres that the use of chlorine was a mistake; the wind more often blew against German forces than with it, so the gas weapon would be more difficult for Germany to use than it would for the Allies. Further, chemical weapons are more effective when used by a military that enjoys disproportionate strength over their opponent. In such cases, gases compound the casualties and suffering of the soldiers and civilians they are used against.

Final Thoughts

The Great War saw the major powers of Europe throw their full might at each other in a mass slaughter that lasted from 1914 to 1918. Chemistry changed from a science based on healing and creation into a weapon of death and destruction. Fritz Haber marked the attitude that allowed for that perversion of chemistry to take place when he claimed, "During peace time a scientist belongs to the World, but during war time he belongs to his country."[198] Albert Einstein, a very close friend of Haber, chose not to participate in the slaughter, and condemned the perversion of science into a tool of destruction in the *Manifesto to the Europeans*—even though so few scientists signed the document that it was never published.

Pope Benedict XV was sickened by the loss of life as early as 1914, as he watched his fellow Europeans "strive to destroy one another with refinements of horror," using "the most awful weapons modern military science has devised," not knowing those weapons would soon include gases that cause soldiers to drown in their own lungs. Like Leo Tolstoy, Benedict XV

[198] Peter Herrlich, "The Responsibility of the Scientist," *EMBO Reports* 14, no. 9 (2013):, doi:10.1038/embor.2013.116.

called upon all leaders to settle their disputes without violence, though, once hostilities erupted, he should have known his calls would be ignored.

After World War I was over, the world came to the consensus that poison gases are inhumane and cruel weapons, and all respected world leaders since then have decided to never use them again in conflicts. Unfortunately, the decision to ban chemical weapons was only made in 1926, after hundreds of thousands of people, both soldiers and civilians, were killed by them.

World War I serves as an example of the evil that can occur when science ceases to serve humanity and instead serves the whims of one's nation. Scientific progress can present both good and evil potential, regardless of circumstances. Fritz Haber, for all he did wrong in his life, still created one of the most important chemical processes in history. The Haber-Bosch process, which produced chemicals that were used to kill hundreds of thousands of people in World War I, has since allowed the world to feed at least 2 billion more people than it otherwise could have.[199] Carl Bosch exemplified this sentiment best in 1932, when, in regards to the Haber-Bosch process, he stated:

> I have often asked myself whether it would have been better if we had not succeeded. The war perhaps would have ended sooner with less misery and on better terms. Gentlemen, these questions are all useless. Progress in science and technology cannot be stopped. They are in many respects akin to art. One can persuade the one to halt as little as the others. They drive the people who are born for them to activity.[200]

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[199] Vaclav Smil, "Global Population and the Nitrogen Cycle," *Scientific American* 277, no. 1 (1997): 81.

[200] Unternehmensarchiv der BASF AG, Signatur W1. December 16, 1932; as cited in Peter Hayes, "Carl Bosch and Carl Krauch: Chemistry and the Political Economy of Germany, 1925–1945," *The Journal of Economic History* 47, no. 02 (1987): 356, doi:10.1017/s0022050700048117.

Part II: WPI in the Great War

Uncovering of WPI's Wartime History

Worcester Polytechnic Institute (WPI) is one of the oldest engineering and technology universities of the United States, founded in 1865 and situated in Worcester, Massachusetts. As students attending WPI, we learned during freshman orientation that the campus had a long history of innovators and engineers, such as Robert H. Goddard, Elwood Haynes, and R. Sanford Riley. During our research on the impact of the Great War on home front in the United States, we were reminded of the metal plaque on campus hanging on Boynton Hall, which was a memorial to honor students who lost their lives during the Great War. Inspired by the monument, we decided to visit the Gordon Library Archives, which holds many newspapers, journals, and books dating back to the founding of WPI, in order to learn more about the campus perspective and WPI's wartime atmosphere. Through researching in the archives we discovered an interesting story of WPI's past, which we believed was worthy of having its own section in this paper. The story we uncovered fits well with the themes and ideas presented in our paper, and it allowed us to make personal connections to events that occurred more than a century ago.

The Outbreak of War

War erupted in Europe on August 4, 1914, and many professors at Worcester Polytechnic Institute were overseas when it did. The outbreak of war had put some of those professors in a precarious position; they were not specifically barred from leaving Europe, but they were not necessarily safe crossing a war zone either. Doctor A. Wilmer Duff, a physics professor, was in Germany when the war broke out, and he was able to see Germany's wartime preparation before returning home via a "very indirect route".[201] Dr. O. W. Long and Dr. Masius, Professors of

[201] *The Journal of the Worcester Polytechnic Institute* 18 (November 1914): 30-31, 288.[Hereafter, all references to uncredited articles in this publication will be cited as *The Journal* vol number (year): page number(s).]

Modern Languages and Head of the Physics Department, respectively, also managed to return safely from Germany, noting their excellent treatment by the German people.[202] Additionally, Dr. Ewell, Professor of Physics, and his wife were in England when the war began, and were able to see the wartime excitement from "various phases".[203] Fortunately, the Institute did not lose any professors or students to the initial wartime hostilities.[204]

Many WPI alumni reported various personal difficulties and adventures brought forth by the war. One former student, Billy Buzzell, was in Germany when war began, and he recalled hiking across Belgium to escape from Germany. Buzzell escaped, partially by train and partially by foot, all the while trundling a wheelbarrow behind him containing all of his belongings.[205] Another former student, Chet Inman, was traveling in Switzerland when war broke out. Following a long and uncertain journey by train to Naples, Inman returned to the United States by boat, but not before experiencing seventeen days of the worst food he ever fathomed.[206] For some alumni, such as Chadwick, who at the time was employed by a Canadian company, the war was very damaging economically. For others, such as Jim Cunningham, a member of the US Artillery and Commissary Service, the war helped boom business.[207]

Some alumni were partisan towards the German cause. John E. Case, who had lived in Dresden Germany for many years, wrote to the Journal of WPI that he believed ultimate German victory was certain. Case did not go into great detail describing what he heard, for fear of censorship, but he did write,"German war is being conducted on the most merciful principles be the Kaiser's troops but the reports of great cruelties on the part of the Allies are continually

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[202] Ibid,73, 90;
[203] Ibid, 73.
[204] Ibid, 73, 90, 128; *The Tech News* 6, no. 1(1914).
[205] *The Journal* 18, 48.
[206] Ibid, 69.
[207] Ibid, 56, 64, 306-307.

reaching Dresden and the people there cannot understand how civilized people can do the things reported of the French and English."[208]

WPI's campus curriculum, attendance rate, and campus activity did not significantly change with the outbreak of the war in Europe. There were no immediate calls for students to enlist in the military reserve, nor were there calls for students to conduct research for the war effort. While there were some alumni who expressed their opinions on the war in the Journal of WPI, the campus, like much of the United States, referred to the conflict as the European War.[209] The campus behavior until early 1915 was consistent with President Wilson's goals, who believed that the United States should continue its policy of isolationism, which caused an underfunding of military research and resulted in an unusually small army relative to the other major powers in the world.[210]

Although the United States was separated from the conflict in Europe by an ocean, many citizens and prominent figures, such as Former President Theodore Roosevelt and Major General Leonard Wood, pushed the United States to prepare its military for war.[211] Those figures believed the United States would not be able to turn a blind eye to the war forever, and after the sinking of the RMS Lusitania on May 7, 1915, along with the German atrocities in Belgium, as

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[208] Ibid, 146.

[209] The European war was not discussed in the WPI *Tech News* Volume 6 No 3-17, spanning from September 29, 1914 to January 26, 1915, which was partially influenced by *The Tech News*'s being apolitical. *The Tech News* 6, no. 3-17(1914-1915). However, future editions of The Tech News contrarily did start discussing the war and campus military preparation. *The Tech News* 7, no. 9(1915). In the WPI *Tech news* V6 No 2, there was discussion of students attending a "Student's' military instruction camp," but the camp was established by the US War Department in 1913. *The Tech News* 6, no. 2(1914). In the yearly report by the President of WPI Ira N. Hollis on January, 1915, he discussed typical changes to the curriculum, attendance numbers, professors, and the departments, and did not mention the war in any way. *The Journal* 18, 73-96. An article written in March 1915 called "What kind of job do I want?" did not discuss any roles call to work in the military, but rather just discussed how WPI students should find their place in the workforce, discussing various jobs such as manufacturing, instructional work, fire protection, government work, business work, sanitation, or politics. Ibid, 165-171. The attendance numbers were also very similar to previous years. Ibid, 30-32; *The Tech News* 6, no. 1(1914). In the Journal, the only initial discussion of the war were alumni and professors discussing their escape from the hostile countries. *The Journal* 18, 45-72.

[210] Kevles, 103.

[211] Theodore Roosevelt, *America and the World War* (New York: Charles Scribner, 1915): x.

described in British propaganda, more Americans began discussing the merit of preparing for war. . On June 9, 1915, WPI held a banquet surrounding the fiftieth anniversary of the founding of the institute and the American Civil War. President of WPI, Ira N. Hollis, who served in the Navy for 15 years, invited various people to speak at the event, including President Wilson. Unfortunately, President Wilson was unable to attend due matters surrounding the sinking of the Lusitania.[212] However, Major General Leonard Wood was able to make it to the banquet, where he indicated his belief that the United States should invest in a stronger military in case of war and in assurance of peace. Major Wood indicated he was doing everything he could to introduce military training at colleges and schools, including starting rifle shooting in public schools.[213] Additionally, Ira N. Hollis spoke about how she believed war undoubtedly assisted material progress and "may give rise to a nation a new birth into greater freedom and higher moral purpose", citing the United States Civil War.[214] In the banquet, Arthur D. Little, a prominent chemist at the time, discussed how he believed the United states was lagging behind the rest of the world in certain areas, and further argued the United States was humiliatingly dependent on German chemical product imports. Still, Little remained optimistic towards future American chemical preeminence.[215]

In late 1915, with great uncertainty surrounding the war and the campus, WPI President Hollis made it clear that it was his duty to ensure the campus was prepared for the worst. In 1915, President Hollis often discussed the role young, trained engineers played in wartime preparedness, as well as how war could be forced upon them.[216] Additionally, President Hollis

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[212] *The Journal 18*, 189-192, 278; *The Tech News* 6, special no. 2(1914).
[213] *The Journal* 18, 389-395.
[214] Ibid, 328-329.
[215] Ibid, 385-388.
[216] *The Tech News* 7, no. 9(1915).

invited General Wood to speak to WPI students at an event planned for November 13, 1915. General Wood spoke to the students about the preparedness movement, each citizens' duty to his or her country in time of war, and the inadequacy of a regular army to protect the country, specifically noting the importance of trained men for officers. President Hollis excused all seniors, juniors, and sophomores from their classes to attend General Hollis' speech, and the Atwater Kent building was filled to maximum capacity. Afterwards, the freshmen class also had their own individual session with the General.[217] President Hollis also preached military preparedness off campus. On November 19 he, along with President Maclauren of MIT, spoke in front of an audience of 2000 people at Mechanics Hall in Worcester, Massachusetts, emphasizing the necessity for a stronger national defense and urging public officials and congressmen to realize the inadequacy of the United States armed forces.[218] As a result of national propaganda for preparedness, on December 3, 1915, more than 250 Worcester business men, including WPI professors A. W. Ewell and A. D. Butterfield, met in the State Armory to organize a course of study for a Worcester Military Training School.[219]

The war also brought about many new technologies, which made their way into the lectures and discussions around campus. In May, 1915, WPI published an article about new submarine technologies in the "European War".[220] On November 23, 1915, the campus held a lecture discussing how crippled soldiers could still be useful. The lecture was given by an engineer that spent the previous fifteen months in German trenches studying the wounded soldiers.[221] An article in March, 1916, was published in the Journal discussing the role of

[217] Ibid; *The Tech News* 7, no. 10(1915).
[218] *The Tech News* 7, no. 11(1915).
[219] *The Tech News* 7, no. 13(1915).
[220] *The Journal* 18, 262-273.
[221] *The Tech News* 7, no. 11(1915).

chemistry in the war, and included questions as to how Germany was obtaining its nitrogen, given the country was being blockaded by the British.[222] In October, 1916, Professor Jennings, Director of the Department of Chemistry, discussed the impetus of Chemistry in America in regards to the war in Europe at a WPI Chemical Club meeting.[223]

By the start of 1916, students were beginning to be called forth to enter into military training. In March, nearly all WPI students received a prospectus and a enrollment blank from the War Department, inviting them to attend a training camp that would allow each student to combine technical education with military training to be of value in time of necessity.[224] In May,1916, President Hollis introduced and encouraged students to take a new class, titled "PHYSICAL EXERCISES AND MILITARY DRILL AT THE INSTITUTE", noting it was necessary to "mark a departure from the old order at the Institute".[225] President Hollis believed that such schools as WPI were necessary to form a "natural supplement to West Point" during the possible emergence of war, and believed that military science and drill courses for students were necessary to fill in "the skeletal organization of officers for active service"[226]. In November 28, 1916, Former President William Howard Taft came to WPI to speak of "The League to Enforce Peace"[227]. Still, even with all of the talk of war on campus, the attendance rates for 1915 and 1916 were rather ordinary. [228]

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[222] *The Journal* 19 (1915): 207-229.
[223] *The Journal* 20 (1916): 47-48.
[224] *The Tech News* 7, no. 26(1916). Institutions of higher education other than WPI also additionally went through a similar call for military preparation. On In March 6, 1917, there was supposed to be a debate between Fordham, Georgetown, Colgate, Syracuse, Pennsylvania, Cornell, and Columbia, that compulsory military training be established in the United States, but nobody would take the negative side of the debate. Likewise, Yale and Harvard had a large majority in favor of universal military training. *The Tech News* 8, no. 21(1917).
[225] *The Journal* 19, 291.
[226] *The Journal* 19, 300.
[227] *The Tech News* 8, no. 11(1916).
[228] *The Tech News* 8, no. 2(1916).

Although President Wilson campaigned with promises of peace and neutrality, he began to give way to some sentiments of the war preparedness movement. September 20th, 1916, marked the first meeting of the National Research Council of the United States. Founded by President Wilson to organize and catalogue all of the available resources and scientists, the council was designed to utilize "the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare."[229] The research council membership was to consist of government officials, various military branches, private research laboratories, and universities, though the council would not actually begin any research until after the United States entered World War I.[230]

Tech students were often persuaded into taking part in the war effort and joining the Army and the Navy, but were generally dissuaded from joining as a standard combatant. In February 26 of 1917, President Hollis held a speech in the WPI gymnasium, where he explained that most technically trained men would find their greatest usefulness outside the actual firing line. Nevertheless, President Hollis noted that no attempt should be made to deter men with an especial aptitude for military work from enlisting in the regular army.[231] Another preparedness article on March 13, 1917, called for all WPI students to fill out blanks with information of all specialized training qualifications, such that, in the case war, students could contribute in the most effective way. Additionally, the article discussed how West Point cadets would not be called until the very last extremity in the war, just how Germany did not enlist undergraduates, and learning from the mistake England made by sending men with special qualifications

[229] George E. Hale, "From the National Research Council," *Journal of the Society of Mechanical Engineers* 39, no. 1 (1917): 432.
[230] Ibid, 433; Amos, 38.
[231] *The Journal* 20, 204.

indiscriminately to the battle lines.[232] A lecture presented on March 28, 1917, by an Army Officer discussed the duties of the numerous departments of the army, and how it was necessary for the army to develop electrical and mechanical devices and to perfect existing devices. About three hundred students and members of the faculty attended the lecture.

WPI Enters the "European War"

On April 11, 1917, Military drills started off with a bang. Of the one hundred and fifty men who showed up to the first campus drill, Drill Master Lieut. L. W. Russell started picking his on-campus officers for the Freshman and Sophomore companies. Additionally, President Hollis spoke to the members of the Senior class on April 9th about ways they might best serve their country. Nearly half of the seniors signaled their intention to take the examination required for the position of Second Lieutenant in United States Army. President Hollis told the Seniors who wanted to go directly into industrial work that they should go into manufacture of munitions or to an engineering branch in the army, but urged all underclassmen to stay with their studies. Technically trained men would be in great demand in the near future, and Hollis believed underclassmen would best serve if they completed their studies before heading to the military.[233] President Hollis himself assumed some additional responsibilities; he was "named by Secretary of War Newton D Baker as one of a board of six men to study coast defense fortifications on call of the President of the Army War College in Washington President Hollis went to Washington April 25 in this service".[234]

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[232] *The Tech News* 8, no. 22(1917).
[233] *The Tech News* 8, no. 26(1917).
[234] *The Journal* 20, 278.

As the United States entered the war, so too did it enter an arms race, and both required the organization of all its scientists and resources. *The Tech News* of WPI for April 26 discussed the chemists usefulness in the time of war, noting each chemist was vital to creating explosives, and manufacturing medications, as well as basic research. The American Chemical Society asked each member to give their qualifications and urged every chemist not already part of the society to fill out a blank and return it to the Bureau of Mines.[235] The National Research Council was also put into full swing and was enabled to coordinate research efforts across the United States. On May 8th, in response to the request of the NRC, President Hollis appointed a research committee at WPI, to whom the National Research Council could assign problems once the organization was perfected. The organization of the committee was referred to the Executive Committee of the Worcester Chapter of the Society of Sigma Xi, who generated a complete index of facilities and specialized professors available on campus. The NRC performed similar cataloging of all educational institutions and industrial laboratories in and about Worcester.[236]

In April through May, 1917, a committee simply called "The Committee", which consisted of WPI faculty, voted on matters regarding how WPI could best contribute to the war. The committee considered the solutions such as the early closing of the Institute and the excusing of students from Institute work that they may enter national-defense service, but resolved that the Institute was a school of engineering, and its courses were no less important in times of war than in peace. Additionally, the Committee determined, while some students felt as though it was their duty to enlist in the Army or Navy, or to take part in the manufacturing of munitions, the freshmen, sophomores, and juniors could best serve by remaining at the institute, stating "this is by far the most effective kind of national and patriotic service that the great

[235] *The Tech News* 8, no. 27(1917).
[236] *The Tech News* 8, no. 29(1917).; *The Journal* 20, 259-264.

majority of these students can now perform".[237] Specifically, The Council believed that seniors were more experienced in engineering than over 99% of men of their age, and should stay in the United States to perform those engineering related tasks.[238]

After the introduction of war, many students left for war service, and clubs such as the Southwestern Society of Engineers were missing about 20% of their membership by October, 1917.[239] In December,1917, WPI tabulated the grades of all students from 1908-1917, and every student of military age whose grade was above 76.2%, or the top third of students, was given deferred classification on enlistment in the Engineering Reserve Corps until they graduated from the institute.[240] There was also an increase in the anti-German sentiments towards the end of the war, with one student writing in May, 1918, that conflict was "indeed a righteous war" and another in July, 1918, stated "I brand Germany as having repeatedly and broken every existing law of God or man".[241] The war caused the original two term year of the school to be changed into a three term schedule, under the direction of the War department.[242] The war also drastically impacted the attendance rate of the campus. In 1914, there the Institute held approximately 541 students, but by January, 1918, only 418, of whom only 115 were not connected to the army or navy, remained, falling again in September to 352 students.[243] Of the 63 students that graduated

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[237] *The Journal* 20, 270-271.
[238] Ibid, 270.
[239] *The Journal* 21 (1917): 66.
[240] Ibid, 161.
[241] Ibid, 21, 213, 277.
[242] Letter from Ira Hollis, the president of WPI to the principal of Dover High School, November 20, 1918, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.; *The Tech News* 10, no. 1(1919).; Letter from Professor Hollis to the students of WPI, September 10, 1918, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.
[243] *The Journal* 18, 32; *The Journal* 22(1919):16; *The Tech News* 9, no. 17(1918).

in June 1918, only 15 were not in direct service to the Government or working towards military and naval preparedness as chemists or munitions and ship manufacturing.[244]

By January 1918, many of WPI's professors and alumni were relocated, in accordance of the needs of the research needs of the United States, and many soon resided in Washington, where the most secret and classified research was being performed.[245] WPI faculty and alumni studied technologies such as submarine detectors, guns, poison gas manufacturing, and unspecified forms of naval research. As the war progressed, a greater number of professors were moved from campus to assist the government, and ultimately, 8 were posted out of campus.[246]

Additionally there were some professors assisting the research and manufacturing needs of the war on campus, and many of the student facilities were transformed to better aid the war effort. In June, 1918, President Hollis spoke at the Forty-Fifth Annual Dinner noting that "He also stated that the Washburn Shops have done some the most important war work in the whole country."[247]

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[244] *The Journal* 21, 305.

[245] Ibid, 6.

[246] *The Journal* 21. "Prof. AL Smith was called to Washington January 19 to work with a committee of Engineering Research the National Research Council. He spent one week the particular task assigned to this group of workers." Ibid, 145. "Sidney W Farnsworth of the Westinghouse Electric Co is now assistant to the secretary of a special naval board of the National Research Council located at the submarine base in New London Conn where he is testing submarine devices." Ibid, 76. "From the great number of nominations received, eighty five names were selected by each of the following organizations: Naval Consulting Board of the US National Research Council American Institute of Electrical Engineers. From the names thus presented, one hundred were chosen to receive commissions. WPI is glad to be so well represented." In June, 1918, six of WPI's professors left campus to assist the government. Ibid, 178-179. On November 1917, it was written: " It was voted that leave of absence be granted to all of instruction at the Institute who enter the of the United States Government during the war this action already fall the cases of Professor D Butterfield who has been appointed a captain the non flying section of the Aviation Corps and John A Spaulding who has been drafted." Ibid, 46. In June of 1918, President Hollis spoke at the Forty-Fifth Annual Dinner, noting that "six professors were now in the service of the Government, three of them in France, Professors Field, Ewell, and Carpenter; Professor Spaulding at Camp Devens, Professor Duff in Washington, Prof H. B. Smith in New London. Ibid, 303-304. Around 3 months later, it was also said "Eight of our instructors at the time when war was declared are now in active war service." Ibid, 307.

[247] *The Journal* 21, 303-304.

In regards to Chemical Warfare

The usage and research of poisonous and asphyxiating gases were not a common topic of discourse on campus, but many WPI chemists contributed in their own ways.[248] The most notable of the WPI chemists working on poison gas was Professor Walter L. Jennings.

Walter Louis Jennings received his Ph.D. of chemistry at Harvard University in 1892.[249]After attaining his Ph.D, Dr. Jennings went to Germany for additional "post post graduate" work at the University of Berlin in 1893, where he studied alongside famed chemists Victor Meyer at Heidelberg and Emil Fischer at Berlin. Another chemist, Emil Discher, was so impressed by Dr. Jennings, that he invited Jennings to become an assistant at his own private laboratory.[250] Dr. Jennings was very well esteemed by many Germans in Heidelberg and Berlin, as Jennings amazed them with his tennis skills. The initials W. L. J. were carved on many tennis rackets and prize loving cups in Heidelberg and Dr. Jennings even found his wife there.[251]

After completed his studies in Germany in 1894, Dr. Jennings found himself in London, where he was approached by the then-director of the Department of Chemistry at WPI, Leonard P. Kinnicutt. Kinnicutt offered Jennings a job at WPI as a professor of organic chemistry, in place of George D. Moore, who was retiring.[252] Jennings enthusiastically accepted the offer, and served as an assistant professor at WPI from 1894-1900, professor from 1900-1937, and was eventually appointed Director of the Department of Chemistry in 1911, following Kinnicutt's

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[248] Generally, the United States was not very much against the usage of poisonous gases in warfare. Amos, 365.
[249] *JENNINGS, Walter Louis*. Biography from the WPI Archives, 1944, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.; *WPI Alumni Association Biographical Records of Walter Louis Jennings*, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.
[250] Leon V. Quigley, "American Contemporaries, Walter Louis Jennings," *Industrial & Engineering Chemistry* 23, no. 2 (1931): 244-255.
[251] Ibid, 244-245.
[252] Ibid, 244-245.

death. Throughout his years at WPI, Jennings was a well-regarded and very involved professor who participated as a member in many organizations.[253]

Upon the American introduction into the Great War, Jennings was assigned by the National Research Council and the Bureau of Mines to perform research on gases as part of the Offence Chemical Research Division as a director of the Chemical Warfare Service, with student Walton B Scott as his assistant.[254] Jennings was reportedly performing intense organic research which kept the "home fires" burning in the Salisbury laboratories around the clock.[255] Professor Jennings' largest published contribution to the war effort was finding an improved method of preparing cyanogen chloride, an extremely poisonous gas. It is unclear when, during the war, he discovered the technique, but it was published in the *American Chemical Society Journal* in 1919.[256] Professor Jennings's contributions was said to have made invaluable contributions to the Allied Cause and brought great pride to the school.[257]

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[253] *JENNINGS, Walter Louis*. Biography from the WPI Archives,1944, A17903 426009; *WPI Alumni Association Biographical Records of Walter Louis Jennings*, A17903 426009. Quigley, 244-245. including Sigma Xi, the American Academy of Art and Science, the American Association for the Advancement of Science, the American Chemical Society, the German Chemical Society, the Worcester Medical Milk Commission, the Worcester Harvard Club, The Bohemians, the Worcester Tennis Club, The Cosmopolitan Club, the Worcester Engineering Society, The Massachusetts Medico-Legal Society, and Ouroboros. Ibid. Jennings was also involved in the Sceptical Chymists club with his students.*Certificate of Walter L Jennings from the Sceptical Chymists Club*, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S. WPI students also donated books to the Chemistry Department, specifically thanking Jennings. *A Testimonial to DR. Jennings about students donations of books on Chemical Engineering, in thankfulness towards Jennings*. A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

[254] *The Journal* 20, 259-264; *The Journal* 21,230; Quigley, 244-245; Letter from Walter L. Jennings to WPI President Hollis, April 9, 1920, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

[255] Quigley, 244-245.

[256] *JENNINGS, Walter Louis*. Biography from the WPI Archives, 1944, A17903 426009. Quigley, 244-245.

[257] *Obituary of Dr. W. L. Jennings in an unknown newspaper*, September 2, 1944, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S. After the war, Professor Jennings presented an interesting paper on Chemistry in Warfare where he showed samples of some of the most important chemicals which had been developed for war purposes and gave an account of the part which WPI men had in chemical warfare research and engineering at the Institute and elsewhere. Unfortunately, the paper and lecture were not able to be found. *The Journal* 22, 270.

Following the conclusion to the war, Professor Jennings continued with his research and teaching on the WPI campus until 1937, and passed away in 1944 in Bangor, Maine.[258]

Aftermath - Mixed Feelings

Interestingly, Jennings, even with his connections to Germany, still researched gases he understood would be used against Germans in combat. Jennings is likely a prime example of the change in perspective brought about by the war, while the wartime campus activity at WPI additionally presents a solid representation of the feelings on the war between 1914 and 1918. The campus also highlights the effect on the preparedness movements, transformation of similar college campuses, and the willingness of American scientists to research poisonous gases to aid the war effort.

By the time the war had ended, WPI had essentially been transformed into a War College; nearly all of the students had gone through military training, and many had served in the Army and Military.[259] WPI was taken over by the Department of War and transformed from a

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[258] Jennings was also one of the people responsible for reviewing renowned chemist Emil Fischer's autobiography. *JENNINGS, Walter Louis*. Biography from the WPI Archives, 1944, A17903 426009. Many other students and alumni of the WPI campus also significantly contributed to the war effort in various ways. Alumni CF Vaughn reported to be involved in the building and operating of a poison gas plant, although the kind of gas and location of the plant was kept secret. *The Journal* 21, 335. Kirtland Marsh who has for several months been in the National Army at Camp Devens has just been detailed for special study of gases to be used to neutralize gas attacks by the Huns. Ibid, 86-87. Alumni "Phosphine" Walker worked as a chemist on Gas Defense work making masks. Ibid, 269. "Mr Green told about The Chlorine Plant at the Edgewood Arsenal the SM Green Co of Springfield designed the plant and supervised its construction and operation for the Government. A large number of lantern slides were shown as made from official photographs taken by the Chemical Warfare Service of the US Army. The views ranged from airplane photos of the entire Arsenal to detail drawings of the chlorine cell employed all exceedingly interesting. The chlorine manufactured here was used as the base for the toxic gases mustard, phosgene, chloropicrin etc compounded by the Chemical Warfare Service for loading gas shells. This chlorine plant had a daily capacity of 100 tons of gas about 19 times the capacity of all of the British French and German gas plants combined the plant was completed in record breaking time ahead of contract schedule and is an achievement in which WPI men may take great pride" *The Journal* 22, 283.

[259] *The Journal* 22, 1.

school of engineering to a school for military engineers.[260] Following the conclusion of the war, although they were restricted to eleven hours a week and would never conflict with Academic exercises, military instructions were still being prescribed until the end of the school year.[261] Most of the professors returned to campus shortly after the war, as did a large number of students in the navy and army who wished to continue their studies, many returning as as First Lieutenants, Captains, Majors, or, in the case of Arthur D. Butterfield, as a Lieutenant Colonel.[262]

The immediate aftermath of the war left many from WPI feeling discontent, as they felt their involvement in the war had seriously disrupted campus life without rendering significant benefit to the war effort. President Hollis did not feel as though the militarization of the campus was particularly useful given how short United States involvement in the war was. In an address to the WPI club in Philadelphia in March, 1919, President Hollis summarized the student military service on campus:

> So far as we were concerned I do not think it was a success. There was so much correspondence on the subject and so many orders issued that we did not know exactly where we stood. Furthermore, the interferences by the War Department extended at first into everything, and we could not carry on instruction seriously. It grew to be a habit on the part of the students to say that this was a military camp and not an educational institution. Instinctively the students were thus entirely in the right: this plan of training students for the army was not for the benefit of education or for the relief of the colleges; it was an emergency measure for the training of officers. When one stops to think of the enormous demand for efficient officers in the armies crossing to France it is easy to see why the Committee on Education could not think of the benefit to colleges so much as of the benefit to the army. I should call the whole plan a failure both from the academic point of view and from the military point of view, but it must be kept in mind that we do not know how great a success it might have been if the war had lasted."[263]

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[260] Letter from Ira Hollis, the president of WPI to the principal of Dover High School, November 20, 1918, A17903 425998.
[261] *The Journal* 22, 22.
[262] Ibid, 48, 244-246, 370-393.
[263] Ibid, 208-228.

The student body also took a hit, as there were only forty-four in the graduating class of 1919.[264] There were more than seventeen men from WPI who died in service to their country, of whom four were killed in action or died of wounds.[265] WPI had performed great research and exhibited strong patriotism and unification of the campus at times of war, yet the war was not a net positive for WPI; the fragmentation of the campus and the loss of students to the war left a bittersweet atmosphere around the school. Still, demobilization orders were soon issued by the War Department in December, 1918, and WPI honored the sacrifices of its students with a plaque that to this day can be found on the exterior wall of Boynton Hall.[266]

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[264] *The Journal* 22, 366. The amount of graduates in the previous years are 63 in 1918, 89 in 1917, 80 in 1916, and 93 in 1915. Ibid.

[265] Physical Education instructor Frank Christopher Brough was wounded in a battle in France and consequently died on July 23, 1918. Ibid, 58. David Mijamin Gaskill, president of the class of 1918, died in Brest, France, on October 7, 1918 of pneumonia. Ibid, 87. Arthur Greenwood, alumni of the class of 1909, died of pneumonia followed by influenza on November 12, 1918. Ibid, 74. Sergeant Robert Horner Hogg, alumni of the class of 1910, was killed in action on March 10, 1918. Ibid, 251. Earl Hamilton Karcher, of the class of 1917, died on March 26, 1918 from blood poisoning. Ibid, 311-312. Almon Kemp Lincoln, president of the class of 1920, died in an airplane accident on December 3, 1918. Ibid, 175-176, 262. Thomas Michael Lynch, alumni of the class of 1908, died at his home in Washington D. C. on December 19, 1918. Ibid, 186. John Edward Malone, alumni of the class of 1906, died on October 16, 1918 from influenza. Ibid, 247, 186. Raymond Bardwell Penniman, alumni of the class of 1915, was reported missing on October, 1916, where in fighting alongside the Royal Canadian Regiment about Ypres, he was one of the volunteers selected to lead a movement. None of the officers or men from his company returned. Ibid, 125-126. Albert Randolph Prouty, alumni of the class of 1914 and Graduate Assistant in the Electrical Engineering Department at WPI, died due to pneumonia on November 18, 1918. Ibid, 78. Winfield Mills Putnam, alumni of the class of 1917, died as a Captain of Artillery from wounds on October 20, 1918. Ibid, 312. Bruce Errington Stephens, of the class of 1922, died on November 10, 1918 from influenza. Ibid, 63. Louis Dominic Tomasi, of the class of 1918, died in January, 1918 from influenza. Ibid, 313. Anson Moulthrop Vibbert, alumni of the class of 1913, died on October 23, 1918 from pneumonia. Ibid, 77. Leon Hubbert Webber, alumni of the class of 1913, died on January 13, 1918 from pneumonia. Ibid, 189.

[266] *The Journal* 22, 22. Between December 10th and 21st all the army men were given discharges. *The Tech News* 10, no. 1(1919).

Part III: WWI - The Centenary Exhibit

Origins of the Exhibit

Most IQPs at WPI are based around the exploration of modern technology, and people often travel to different places around the world for their projects. While our group was trying to figure out the basis of our IQP, we looked at what each of our interests were and found that we all enjoyed history. Two of our group members were particularly interested in the First World War, with one member even having a collection of artifacts from the time period, while the other two members admitted to not knowing very much about that particular era in history. During one weekend we all got together to see some of the artifacts that one of our group members had acquired, and this helped kindle the interest of the two group members who had not known much about the Great War.

We determined that all of us were interested in studying the technological advancement during the First World War and began searching for a professor who would be interested in advising our project. We specifically began looking for an advisor within the history department since our IQP idea was somewhat unorthodox in that it focused almost entirely on the history of a technology rather than the technology itself. Eventually, we found an advisor who was interested in our topic and able to advise us, and he mentioned early on in the process that the IQP could also include an interactive aspect rather than being solely a written piece. After playfully jabbing at our group member for having such a large World War I collection, our advisor suggested that setting up an exhibit at WPI might actually be a valuable part of our project. After discussing the idea amongst ourselves, our group decided that hosting an exhibit around the 100th anniversary of Armistice Day would be an appropriate way to showcase what is often an overlooked part of world history in the United States.

Creating the Exhibit

Before we could begin planning what we wanted to bring to the exhibit, we had to determine a time and place for the exhibit to be hosted. There were two main candidates that our group proposed, which were the Campus Center and the Gordon Library due to the number of people that regularly visited both. After some brief discussion, our group decided that the library would be the most ideal location because there would be more space and it would be quieter.

We worked with the library staff to determine where and when we would be able to host the exhibit. We wanted to get the date of our exhibit to be as close to November 11, the date of the Armistice, as possible. Unfortunately, the 11th fell on a Sunday and we did not believe that many people would show up to the library on the weekend, so we opted instead to have a two day exhibit that would be held on the Friday before the 11th and the Monday afterwords. We also decided that we would have two different sections for our exhibit. The first would be a teaser section that would be put up at the front of the library behind a locked display case for a few weeks before the main exhibit. The second part would be held on the third floor of the library and would be set up on the two chosen days between noon and 6:00 PM each of those days.

Once we had the location and dates for our main exhibit, we worked with the Academic Technology Center (ATC) to create two advertisement posters for the exhibit that were planned to be placed in the library shortly before the start of each event day. The posters were finished before the start of the exhibit and locations for them to be placed were worked out with the library prior to the commencement of the events.

Creating a Survey

As we were planning our exhibit, our advisor recommended that we use the unique opportunity to collect some information on the modern perception of the combat in the Great War. We worked with our advisor to create a short survey that could best address the information we were hoping to find. The survey was split into two parts, with the main aspect being based on the weaponry of the war, and the second part being based on the exhibit we were hosting. The first part of the survey limited responses to checkboxes or numbering in order to keep the interest of visitors to the exhibit. The second part of the survey was more open-ended since people would likely have different experiences and interests and would learn different things from the exhibit.

The main aspect of the survey focused on the different forms of weaponry from the First World War and was designed to be filled out before seeing the exhibit. Our group began creating a survey based around the morality and efficacy of different weapons, but decided to include other forms of weapons that were not necessarily unique to or iconic to World War I. The other forms of weapons were included in the survey because their effects and dangers are known well enough today. For instance, nuclear weapons were not developed until the Second World War, but the people answering the survey would know about them and their dangers, and might compare those weapons to ones that were available in the First World War. By including modern weapons in the survey, any modern bias can be accounted for. A different question asked about the controversiality of certain weapons at the time they were used, and only described weapons that were available at the time of the First World War. The reason we designed a question around the controversy of different weapons was to determine how people today believe people in the past reacted to new weapons. The reaction to new weaponry would have been a unique experience to World War I, as it saw the first major uses of trenches, flamethrowers, chemical

weapons, tanks, and aircraft, and we believed understanding the differences between the modern and historical viewpoint might be important in our investigation. Two other “yes” or “no” questions were asked as well: “Do you think war can be justified” and “In war, do the ends justify the means?” The purpose of the “yes” or “no” questions was to help us decide later whether or not the survey responder was a pacifist, as we believed that would greatly influence the results of the questions on weapon morality.

The second part of the survey was based around the exhibit itself and was designed to be filled out after viewing the exhibit. The survey asked viewers what they enjoyed most about the exhibit and something they learned from the exhibit. These questions were designed to be short and easy to answer, but were not designed for any hard evidence to be gathered from them. Instead, the two end questions were made to help guide us in our investigation by outlining the areas that people did not know much about.

Once the survey was completed, we had to get approval from the Institutional Review Board, or IRB, before the survey could be used to gather any data. We were not very worried about the survey being rejected or about needing to revise it because it did not contain or request any personal information, and after a few weeks the survey was approved for use in our exhibit.

Teaser Case

Figure III.1: The teaser case display including all of the artifacts we used to advertise for the WWI: The Centenary Exhibit.

When choosing items that would go in the front display case, we decided to include eye catching and interesting artifacts so that people walking in to the library would stop and notice them. The most eye catching artifact we had was the "Beat Back the Hun" poster. Although it was not the most well known poster that could have been used, it was incredibly colorful and eye catching. The poster was chosen to be tilted towards the front doors so that people entering the library would be directly facing the poster, and so that the poster could be seen from outside the library. The next item that was chosen was the Purple Heart. The Purple Heart is an item that almost anybody could recognize, making it ideal for the teaser case. As our exhibit was for the centennial anniversary of the armistice, we thought it would be appropriate to include a newspaper from the day of the armistice in order to remind people that the anniversary is coming up, and is the reason for our exhibit.

Another way that we tried to get people interested in our display case was by including some 3D items. For that reason we decided to include a U.S. artillery shell and a U.S. 101st

Infantry helmet. A German Ledermaske was also included as our IQP was largely centered around chemical warfare. The last item we decided to put in the display was a British soldier's diary, as it was small and one of the more interesting items that we had access to as the soldier was wounded in action July 1st, 1916, the first day of the Somme Offensive. After the items were chosen, we wrote descriptions for the items so that people looking at the display could learn more about what they were looking at.

While the display case was up, we noticed that almost everyone entering the library at least looked at the display, and we saw many people stop and read the descriptions of the items. Although we could not get survey results from this part of the exhibit, it was a huge success because of the large amount of people who were seeing the display. One of the librarians even told us that during one of her meetings she was complimented on the fact that there was a display for the centennial and how nice it was, and she told them that it was not the library who set it up, but instead an IQP team.

Main Exhibit

Figure III.2: The main exhibit including all artifacts for the WWI: The Centenary Exhibit**.**

When selecting items for the main exhibit we wanted to provide as complete a picture of the First World War as we could to our audience. In order to accomplish this, we selected artifacts of various origin, size and significance. For example, we chose to bring American, French and German tunics and helmets to represent the different colors and styles of tunics three different countries employed on the Western Front. We also chose to bring American and German equipment to display on the tunics to illustrate the different equipment used by nations. The Germans used leather, the traditional material, for most of their military gear including belts, ammunition pouches, backpacks and the liners and chinstraps of the Stahlhelm. The Americans, on the other hand, used webbed gear, or woven cloth, for their ammunition pouches and backpacks because it was more durable than the traditional leather. We also brought the aforementioned artifacts to allow the audience to see what the soldiers on the Western Front looked like. Typically when World War I is studied it is through black and white or colorized photos or film. We wanted our audience to see what the soldiers would have worn in battle in 1918 to help the audience connect with a war that is often bypassed in the United States.

Figure III.3: A comparison of German and American uniforms and equipment as would have been seen in 1918 on the Western Front.

We also brought helmets based on the same idea of the tunics. We wanted to show our audience different perspectives and different styles of helmets used by different nations throughout the war. For example, we brought a German M1895 Pickelhaube to illustrate the early perception of the war. In 1914, militaries were still based on the Napoleonic style of dress as well as tactics, emphasizing artillery barrages and massed infantry charges. The Pickelhaube, with its polished brass fittings offered little protection and was unsuited for modern war. This led to the development of the modern steel helmets, the Adrian, Brodie and Stahlhelm. The Adrian helmet, first employed by the French in the fall of 1915 was designed to offer all around protection for troops, though it did not offer a lot of protection for the neck. The Brodie helmet, first employed in 1916 by the British and later used by the Americans, offered protection against shrapnel and overhead shells but offered little protection against fragments exploding close to the ground. Finally, the German Stahlhelm, introduced in 1916, offered all around protection and

employed more steel than the Adrian and Brodie helmets, however, the shape of the Stahlhelm resulted in a bell-like ringing for soldiers wearing the helmet if a shell exploded nearby. In our exhibit, we wanted to show these differences as well as the different colors and sizes of the helmets to give the audience a better perspective on the various styles of helmets nations employed during the war and how they were developed.

We also brought in artifacts that had significant history to help the audience relate to the war. One set of artifacts we brought consisted of an American tunic, overseas cap, gas mask, trousers, puttees and a service certificate all belonging to one soldier from Boston, Massachusetts as seen in Figure III.4. The soldier lost his leg during the war and this collection of artifacts gave the audience a chance to connect with one of the approximately 20 million soldiers who were wounded during World War I. Another historic artifact we brought in was a death plaque given to the next of kin of a British sailor killed during the war. This soldier was killed only a few days after Britain entered the war in 1914 and he served on the H.M.S. Amphion, first British ship sunk during World War I.

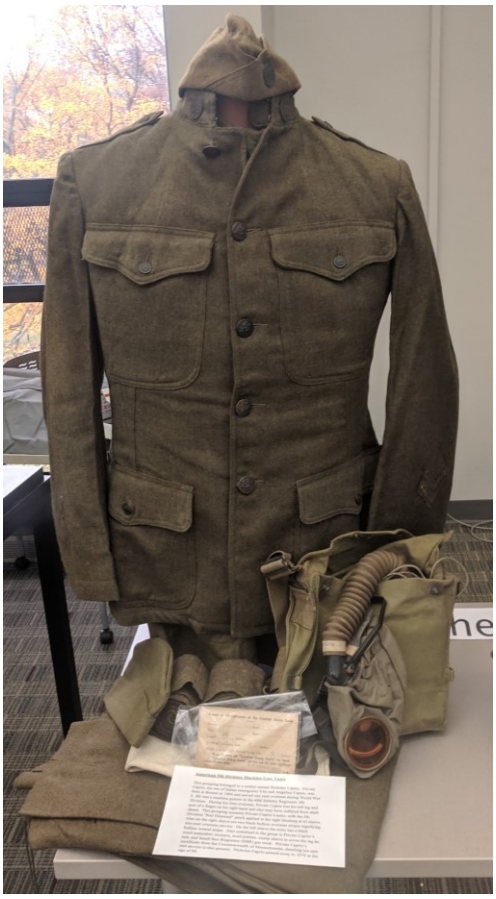


Figure III.4: The tunic, overseas cap, pants, and gas mask of Pvt. Nicholas Caprio. Pvt. Caprio was from Boston, Massachusetts and lost his leg during the war.

Figure III.5: The Death Plaque and documents of Stoker 1st Class Robert Ashton who was killed when the H.M.S. Amphion struck a German mine on August 6th, 1914. The H.M.S. Amphion was the first British ship sunk during World War I.

Taking into account our IQP focused on the evolution of gas and chemical warfare during World War I, we included them in the center of our exhibit. Similar to the tunics, the gas masks were meant to show the different ways militaries protected their soldiers during World War I. For example, the German Ledermaske and Gummimaske are extremely similar to each other, barring a few small changes, and are similar to some styles of modern gas masks, while the U.S. and Britain used a multistage filter in a canister to protect from gas. Our exhibit wanted to show that even though the approach to defending against gas was different, the gas masks still performed the same task: protect the soldiers.

Figure III.6: Examples of German and American gas masks from World War I. From left to right: German M17 Ledermaske, German M15 Gummimaske, American Small Box Respirator.

We also chose some artifacts for their notoriety or fame within the First World War. We chose to bring the famous “Remember Belgium” poster by Ellsworth Young not only because the poster is famous for capturing German brutality during the war, but also to contribute to our main essay where we consider just war theory and the idea of fighting a war fairly. Another artifact we brought was a complete Princess Mary Tin smoker’s set from 1914. This artifact is from one of the most famous events of World War I: the Christmas Truce. A few days before Christmas in 1914, there was a spontaneous truce across the Western Front between the British, French and Germans. During this truce, soldiers fraternized, drank, smoked and played soccer

matches. This event represented one of last moments of humanity during the war. After this event, leaders of the warring European nations issued declarations stating soldiers fraternizing would be shot. Though some spontaneous truces sprung up during Christmas of 1915, they were not on the same scale as the 1914 truces.

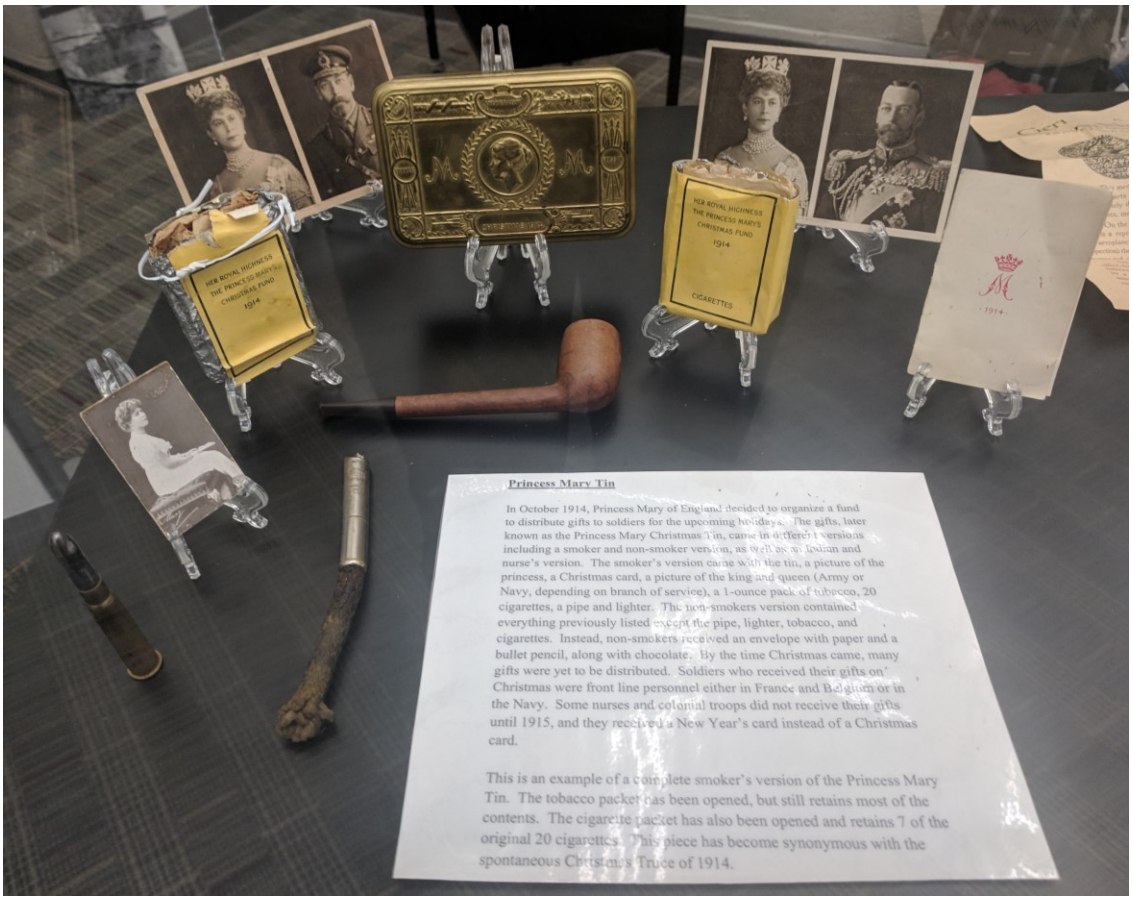


Figure III.7: A complete example of a Princess Mary Tin smoker's set, as issued to British troops during Christmas 1914.

Finally, we chose to bring a British copy of the German medal commemorating the sinking of the Lusitania. This artifact, used as a propaganda tool by the British and sold for one shilling, was meant to increase public support against the Germans after the liner H.M.S. Lusitania was sunk by a U-Boat just off the English coast. The British claimed the Lusitania was only a passenger ship and was not carrying war material and the Germans violated international

law and sunk it without warning. This event signalled a shift in American trade and perception of the Germans. Until this point, the U.S. traded with both the Entente and Central Powers, but after this event, which claimed the lives of some 120 Americans, the U.S. traded almost exclusively with the Entente Powers. In the U.S., perception of the Germans also changed as Americans became more suspicious of Germans, even those living in the United States. This contributed to the passage of Prohibition in the 1920's as many of the breweries in the U.S. were German owned.

Figure III.8: An example of the British copy of the German medal commemorating the sinking of the Lusitania. This example retains its original box as well as the pamphlet pointing out key features on the medal as well as accusing the Germans of premeditating the attack.

Overall, we chose artifacts to bring to the exhibit not only based on their relevance to our project but also based on their appearance, origin, fame, notoriety, and significance within the context of the First World War.

Hosting the Exhibit:

The first day of the exhibit fell on Friday, November 9th, and started slightly later than the advertised time because it took us longer to unpack and set up all of the artifacts than we had initially planned. Bringing the artifacts up to the top floor of the library did not take very much time, but because only one of our group members had any prior experience manipulating and displaying the artifacts the set up took about an hour longer than expected.

Much of the equipment required special care to manipulate and often came with unexpected challenges that impeded our progress during the setup. For instance, one of the artifacts that we brought was an American military coat complete with its backpack and gas mask. The coat was fairly easy to place on the mannequin, but the challenge came when we placed the backpack on the mannequin only to find that it caused the display to become top heavy enough that it could not stand on its own. Similarly, many of the gas masks, while most were still flexible enough to be opened, were stiff. Their rigidity made it difficult to open them up enough that visitors to the exhibit would be able to see the masks properly, and we struggled to keep them open while taking care to not destroy any of the masks.

While the exhibit was not completely ready by the advertised time, that did not prevent some onlookers from asking questions about the artifacts as we were unpacking them. Some of the people who came during the setup were actually able to see different aspects of the equipment than would be visible on a static display. The main example that we recall was being able to show some of the inner markings on one of the American coats which showed the soldier's name in faded pen.

Once the exhibit was completely set up, we were able to spend more time actively looking for questions to answer and were able to point out some of the more subtle aspects of

some of the artifacts. The exhibit was not set up to have any particular flow to it, but over time we saw that there were a few artifacts that stood out to most people. We found that most people had taken an interest two distinct parts of the exhibit: the French coat and the American machine gunner coat.

The French coat was actually the newest addition to our group member's collection. The coat was obtained about two weeks before the start of the exhibit and it seemed to be the most eye catching artifact that we brought. When we spoke to a few visitors to the exhibit, we noticed that most people seemed to like the sky blue color of the coat compared to the gray of the German coat and the yellowish-green of the American coats. An interesting encounter we had was when one student that was actually from France took an interest in the coat. She said she was very happy to see a display on the First World War since the United States tends to focus more on the Second World War than the first.

The American machine gunner coat did not seem to interest people very much at first because of its color, but the story behind the coat seemed to be a uniquely interesting aspect of it. Our group discovered the interest when we saw more than a few people all looking at what appeared to be a long sock next to the coat, but nobody seemed to know what it was. People grew very interested when we told them that it was actually more like a compression sock that the soldier who the coat belonged to would have placed over his leg stump after it had been amputated. Our group did not know exactly how the soldier lost his leg, but we were able to explain that it was likely for him to have lost it during an artillery strike due to his position as a machine gunner. We were fortunate that we brought that artifact because it allowed us to show a more personal side to the war while also explaining some of the military logistics of the time,

and many people may have felt a small personal connection to the soldier because he had also been from Massachusetts.

Not all of the visitors to our exhibit were students, we also had a few history professors view the displays and ask questions. There were some major differences between how most students saw the exhibit and how most of the professors viewed it, as the professors universally read every word we had written on every artifact and did not hesitate to ask questions if something interesting caught their eye. Many of the questions that the professors asked were also directed at our own views of the war rather than any individual artifact. For instance, some professors asked us what we found to be the most interesting part of the war or why we decided to host the exhibit in the first place.

Between the two days that the exhibit was up, not very much changed in terms of the questions people asked or what people found interesting, but there was one encounter that spanned both days and was the most unique experience for our group during the event. Soon after the displays were put up on the first day of the exhibit, a professor started looking at the displays and began asking us questions about the various artifacts and our own interests in the Great War. We all initially believed that he was a history professor, but learned later that he was actually a mechanical engineering professor who just had a strong interest in the topic. He informed us that his father had served in the Second World War on a boat that was originally built in the First World War, and that his grandfather was part of the United States cavalry during the Great War. He spoke to us as a group for what was probably close to half an hour before leaving, but informed us before he left that he was going to search for his grandfather's riding crop that he possessed. Towards the end of the second day, he visited our exhibit again, but brought a briefcase with him. Inside his briefcase he showed us not only the riding crop, which

somehow still had its suede lining, but also an antique book which had listed the date his father's military ship was built. This encounter was probably the most interesting to our group because it was the only time during the event where we were saw a direct connection between the war and the present. Not only did we hear an interesting account of someone's family in the war, but we also were able to see an artifact from that story and documentation that showed the flow from the First World War into the second and finally into the modern day.

Data Analysis:

After the conclusion of the exhibit, we gathered the surveys that were completed and analyzed the results. We created graphs to help organize the data from the first page of the survey into a more easily understandable form.

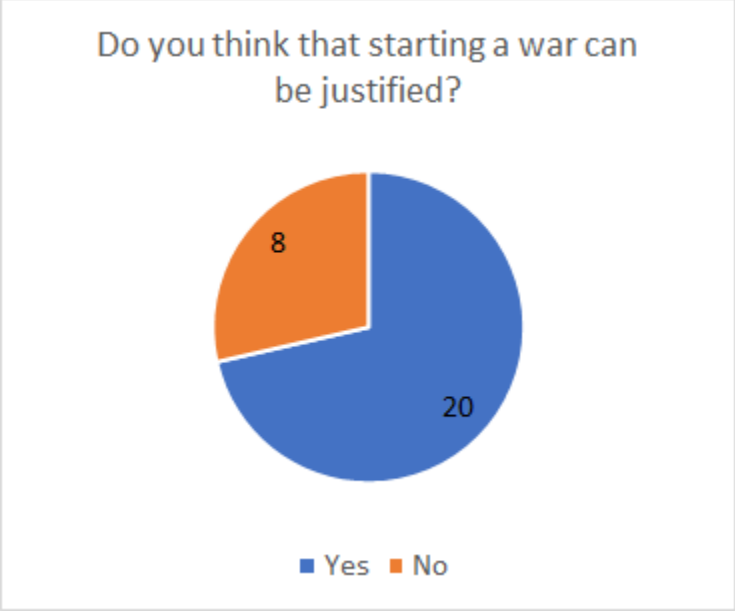


Figure III.9: This pie chart shows the results from Question 1 on the survey.

Figure III.9 shows the breakdown of the responses for the first question of the survey. The results suggest that the vast majority of people are not complete pacifists, and believe that the act of war itself is not necessarily unjustifiable.

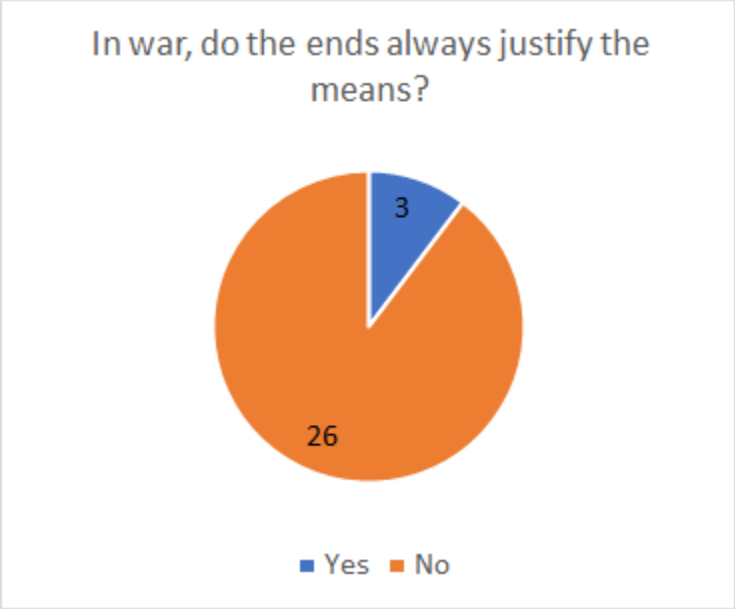


Figure III.10: This pie chart shows the results from Question 2 on the survey.

Figure III.10 shows the results from the second question, which asked whether the ends always justify the means. The data is about what our group had expected to receive, as it suggests that the vast majority of people do not believe that anything should be done in war even if it could result in victory. When combined with the responses from the question about the justifiability of war, the two charts suggest that the majority of respondents do not hold an all-or-nothing view of war; most believe that war can be justified, but that war does not permit certain actions.

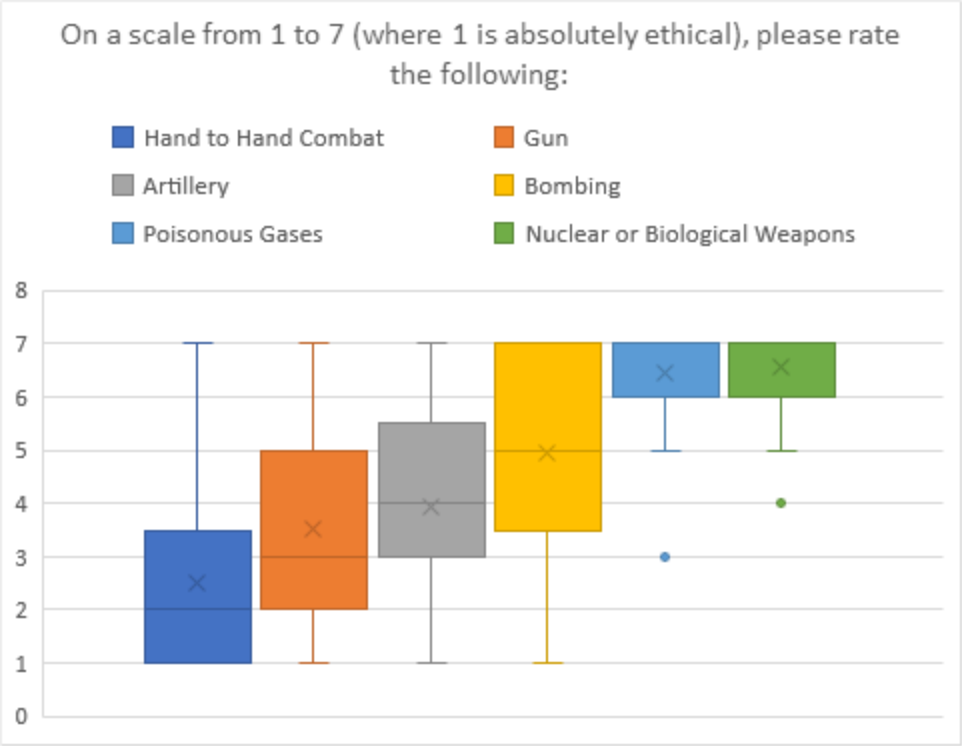


Figure III.11: A box and whisker plot showing the results from Question 3 on the survey, which asked participants to rank the ethicacy of certain weapons from 1 to 7.

Figure III.11 shows a box and whisker plot for the ethicacy of each form of weaponry. The graph shows that modern responses elicit that nuclear and biological weapons are considered to be only slightly worse than chemical weapons. Some errors may have been made during the collection of this data, since the ordering we expected was the order that we placed the responses in, which may have indicated a preferred order in the minds of some respondents. Similarly, the exclusion of chemical weapons from the nuclear and biological weapons helps signify them as being different than the other two, which may have indicated to some people that they should respond with chemical weapons on a lower number since the three are usually grouped together as weapons of mass destruction.

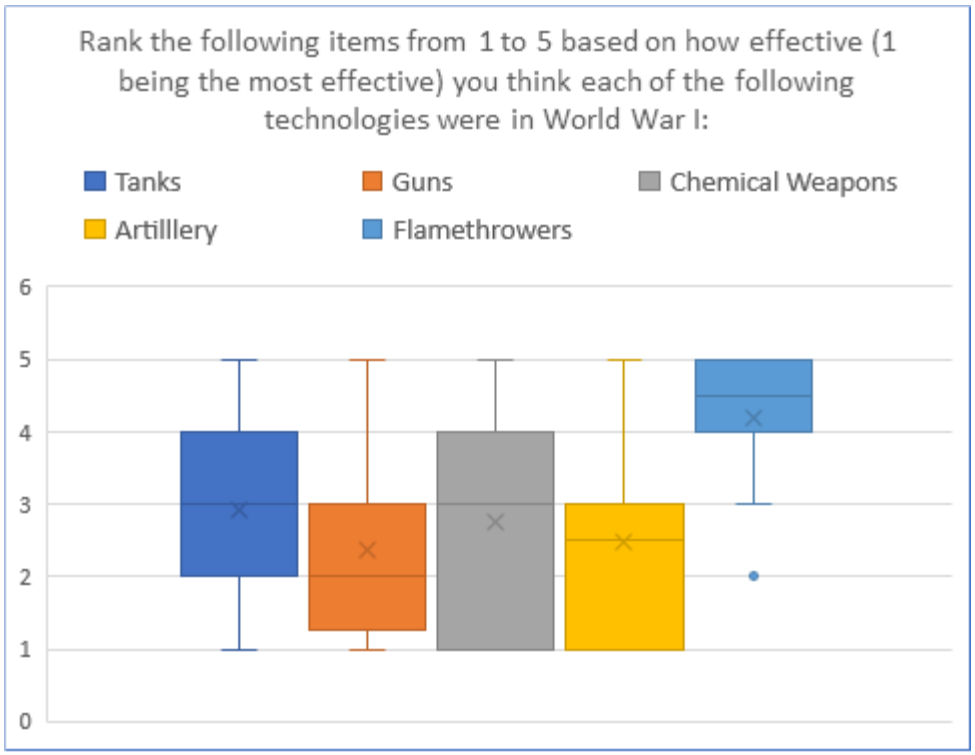


Figure III.12: This box and whisker plot illustrates the results from Question 4 on the survey.

Figure III.12 shows a box and whisker plot for the answers to the fourth question. The graph above shows that there was not a clear consensus amongst the respondents as to the ordering of the effectiveness of the weapons. While the effectiveness of various technologies were debatable, e.g. Tanks vs Flamethrowers, it was clear that many of the respondents did not understand how significant Artillery was. The results to the question may indicate that many of the respondents were not very knowledgeable of the First World War.

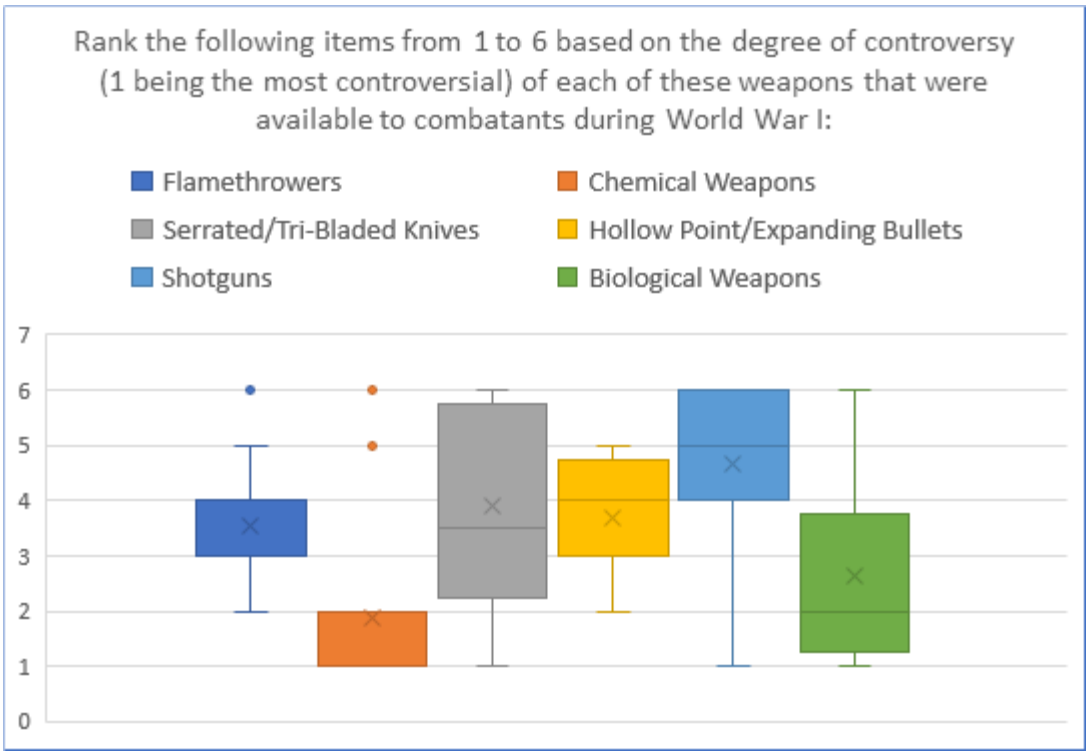


Figure III.13: This box and whisker plot displays the results from Question 5 from the survey.

Our results from the previous question suggest that people believe Chemical Weapons were seen as more controversial than all of the other listed weapons during the First World War.

Our data collection process had notable flaws that likely influenced some of the data. For instance, the survey was designed to be filled out partially before seeing the exhibit and asking questions and partially after, but some people filled out both parts of the survey after having seen the exhibit. Any extra knowledge gained during the exhibit may not be representative of the knowledge that an average modern American would know or think about the Great War, and so the results may be skewed slightly in favor of the results that our group was expecting to find. Similarly, some respondents found it difficult to keep track of the way each question was supposed to be answered. For instance, some did not realize that ranking a list means that only one item from the list can be any given number, or in other cases people numbered their choices

backwards. For the cases where the numbering was backwards, the order was reversed before being entered because our group believed it was obvious enough when this occurred that the data did not need to be thrown away. Instances where the data was obviously backwards were indicated by responses that said, for instance, that hand to hand combat was a less moral way of fighting than using nuclear weapons, and every response past hand to hand combat was perceived as more ethical rather than the expected less ethical.

Finally, some visitors to the exhibit did not fill out survey responses before leaving, creating an error that did not impact the quality of the data received but did impact the quantity. Our group does not have data to reflect the experiences of the people who did not fill out surveys, nor do we have data to reflect how many people did not fill out the survey before leaving, though estimates based on memory indicate that perhaps as many as 30% of people did not fill them out.

Reflections:

Overall, the experience of hosting an exhibit was definitely worthwhile both for our own interest and our IQP. The data that we gathered, while not perfect, is still usable in our discussion and helps us understand how people today look back on the Great War.

If we were to host an exhibit again, we would probably do most things the same way, but we would definitely advertise it earlier and more vigorously. We would also try to talk more to people earlier when one of us thinks they are interested in an artifact, as most of the long conversations we had with people came after we spoke first.

In terms of our own personal growth, hosting the exhibit helped us all understand the history of the First World War better by requiring us to relay our knowledge to others. This experience showed us how even the smallest details can be every bit as important as the overall event when it comes to understanding the nuances of history.

Great War Technology IQP Exhibit Questionnaire

1. **Do you think that starting a war can be justified?**

- ☐ Yes
- ☐ No

2. **In war, do the ends always justify the means?**

- ☐ Yes
- ☐ No

3. **On a scale from 1 to 7 (where 1 is absolutely ethical), please rate the following statements:**

	1	2	3	4	5	6	7
Hand to hand combat is an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐
Guns are an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐
Artillery is an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐
Bombing is an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐
Poisonous gases are an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐
The use of nuclear or biological weapons is an ethical means of fighting.	☐	☐	☐	☐	☐	☐	☐

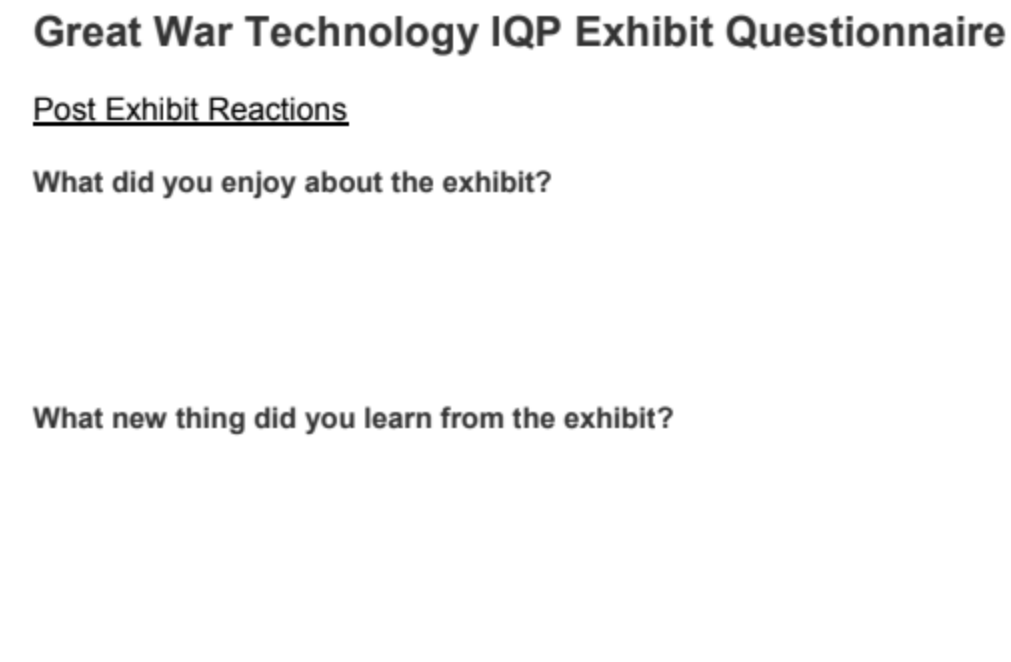
4. **Rank the following items from 1 to 5 based on how effective (1 being the most effective) you think each of the following technologies were in World War I:**

Tanks.	
Guns.	
Chemical Weapons.	
Artillery.	
Flamethrowers.	

5. **Rank the following items from 1 to 6 based on the degree of controversy (1 being the most controversial) of each of these weapons that were available to combatants during World War I:**

Flamethrowers.	
Chemical Weapons.	
Serrated/Tri-Bladed Knives.	
Hollow Point/Expanding Bullets.	
Shotguns.	
Biological Weapons.	

Figure III.14: Page 1 of the Survey



Great War Technology IQP Exhibit Questionnaire

Post Exhibit Reactions

What did you enjoy about the exhibit?

What new thing did you learn from the exhibit?

Figure III.15: Page 2 of the Survey

References

Abbot, Willis J. *The Nations at War*. New York: Leslie, 1918.

This source provides a first hand history of the First World War from 1914 until 1917. The source outlines and narrates the war in Europe and provides information on key events and battles, such as the Battles of the Somme and Verdun and concludes with the Battle of Passchendaele. The source is written from the American perspective and is biased towards certain events, such as the sinking of the Lusitania.

Abbot, Willis J. *The United States in the Great War*. New York: Leslie-Judge, 1920.

This source provides a narrative history of the First World War from the American perspective. The author details key events that led to American entry into the war, such as the attack on the Lusitania and the atrocities in Belgium and provides a history of American forces and the operations they participated in while in Europe, such as the Argonne Offensive.

Adams, Valerie. *Chemical Warfare, Chemical Disarmament* Bloomington: Indiana University Press, 1990.

This source gives a good account of the beginnings of gas warfare in ww1 despite not being primarily about the topic. The book is primarily about how chemical warfare disarmament was done over time and goes into detail about why chemical warfare was not done in WW2.

Arthur, Max. *Forgotten Voices of the Great War*. London: Ebury, 2014.

A source that includes transcripts of interviews from World War 1.

A Testimonial to DR. Jennings about students donations of books on Chemical Engineering, in thankfulness towards Jennings. A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

A WPI archives source describing a testimonial that students gave to Professor Jennings due to what he did for the Chemical Engineering department.

Attendees of the Brussels Declaration of 1874, *Project of an International Declaration concerning the Laws and Customs of War. Brussels*: Brussels: International Red Cross, 1874.

The document that was produced at the end of the Brussels peace conference of 1874 that had the goal of choosing which actions were ethical or unethical during war.

Attendees of the Treaty of Versailles, *Treaty of Peace between the Allied and Associated Powers and Germany. Versailles*, 1919.

The text of the Treaty of Versailles that was signed after the armistice of World War 1. The source is relevant as it shows the extent that Germany was punished as well as the direct chemical warfare restrictions for Germany after the war.

Benedict XV, Pope. *Ad Beatissimi Apostolorum*. Encyclical Letter. Vatican Website. November 1, 1914.

An encyclical letter from the pope in late 1914, asking for peace relating to World War One. Outlines the reasons why peace should be sought for religious reasons.

Boot, Max. *War Made New: Technology, Warfare, and the Course of History, 1500 to Today*. New York: Gotham Books, 2006.

A source about the history of military technology. The section of the book that is particularly relevant is the development of machine guns.

Brooks, Jane. *One Hundred Years of Wartime Nursing Practices, 1854-1953*. Manchester: Manchester Univ. Press, 2015.

This part of the book discusses the various treatments of gassed soldiers and the experiences of nurses during WWI. Treatments including caring for the eyes, as well as burns which caused severe pain and could cause infections are discussed in the article and illustrate the horrors of gas warfare.

Brophy, Leo P., and George J. B. Fisher. *The Chemical Warfare Service: Organizing for War.* Washington, D.C.: Center of Military History, U.S. Army, 2004.

The article examines the development and formation of the Chemical Corps. in the U.S. during WWI. The article discusses the establishment of the training schools and the research and testing facilities the U.S. used to develop and test their chemical weapons.

Brophy, Leo P., Rexmond Canning. Cochrane, and Wyndham D. Miles. *United States Army in World War II. The Chemical Warfare Service : From Laboratory to Field*. Washington: U.S. Government Printing Office, 1959.

This source is about the chemical warfare service in the United States. Although it focuses on World War II, it does have a section on World War I in which it describes the state of military research in the United States during World War I.

Brown, Frederic J. *Chemical Warfare: A Study in Restraints*. Princeton, NJ: Princeton Univ. Press, 1968.

This source largely focuses on propaganda relating to mustard gas, and how the United States did not react as much as planned by the British. The book gives details of the general American view on mustard gas. The book then continues to suggest that the us was not prepared for gas warfare and had to “sell” gas warfare to the soldiers. The source then briefly mentions sciences new role in warfare and why chemical warfare was unethical.

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The book explores many influential just war thinkers through history. For every person, their influences, written texts, ideas, criticisms and influence are evaluated and the authors are compared to previous thinkers through history.

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This source provides information on how the United States public felt about entering World War 1 by giving information about movements and events that happened during that time.

Certificate of Walter L Jennings from the Sceptical Chymists Club, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

The Certificate that Professor Jennings received for joining the Sceptical Chymists. Found in the WPI archives.

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Churchill’s accounts of his experience in the war. Includes letters declassified after the war about the British war departments ideas about using gas warfare and their rejection of gas warfare.

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taboo about the use of poison weapons, such as arrows, snakes, and plants, in primitive warfare and the disapproval that resulted from the use of such weapons.

Coleman, Kim. *A History of Chemical Warfare*. Basingstoke: Palgrave Macmillan, 2005.

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This source talked about how the Great War became a war of chemists and physicians, and how asphyxiating gases would become the evolution of weapons. The source compared chlorine to weapons such as the dum-dum bullet, but did not mention that Germans were the first to use it.

Congressional Record :Proceedings and Debates of the Sixty-Fifth Congress. Washington: Government Printing Office, 1917.

An official US source that is a transcript of what happened during many congressional hearings. It is a good source on US government opinions about aspects of World War 1.

Cook, Tim. No Place to Run: The Canadian Corps and Gas Warfare in the First World War. Vancouver, BC: UBC Press, 2009.

The book gives details on the Canadian perspective of chemical warfare in WW1 from the initial gas attacks to protecting against it to eventually using CW. The book shows that the Canadian ideas on morality and ethics were close to Britain's until the end of the war, but Canada was worried after the war due to their weaker resources.

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This article describes the evolution and development of weapons taboos such as nuclear war or chemical weapons. The article also discusses George Marshall and the lack of use of chemical weapons against the Japanese after Germany surrendered.

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A volume part of a late 1900s study on the problems relating to CBW. Volume 3 is about the Law of war relating to CBW and gives details about what parts of the Hague convention were relevant and were interpreted in WW1. The book also investigates the place of just war in CBW and has an appendix of many international agreements to ban CBW. Volume 4 is about chemical disarmament which could also be relevant.

Elek, Paul. *The Problem of Chemical and Biological Warfare*. Vol. 4. Stockholm: SIPRI, 1973.

This study is part of a contemporary study of the disarmament of chemical weapons. This specific volume focuses on the negotiations and events that took place concerning chemical warfare from 1920 to 1970.

Ellis, John, and Edward Clinton Ezell. *The Social History of the Machine Gun*. Baltimore: Johns Hopkins Univ. Press, 1987.

A book written about machine guns perception and influence rather than technical specifications. Has interesting quotes and statistics about machine guns over many periods of time including ww1.

Elsey, Ena. "Disabled Ex-Servicemen's Experiences of Rehabilitation and Employment after the First World War." *Oral History* 25, no. 2 (1997): 49-58.

This article discusses the long term effects of wounded servicemen years after WWI ended. The article has four WWI British veterans participate in the study and discusses their experience working after the war as well as their rehabilitation and training they received before being discharged.

Freemantle, Michael. *Gas! Gas! Quick, Boys!: How Chemistry Changed the First World War*. Stroud, Gloucestershire: Spellmount, 2013.

The book gives an account of gas warfare mostly from a chemist's perspective. Gives brief history of gas warfare, stats on gas warfare, information of the discovery and use of most of the main gasses, and quotes about the suffering that occurred and whether the gassing was ethical. Also has a section of the early use of tear gas.

Fitzgerald, G. J. "Chemical Warfare and Medical Response During World War I." *American Journal of Public Health* 98, no. 4 (2008): 611-25. doi:10.2105/ajph.2007.11930.

This source is a Journal article about the medical response to Chemical warfare during World War 1. Specifically, the source describes the short term effects of mustard gas, along with how a gassed soldier would be dealt with. As mustard gas created a large amount of casualties, the source gives insight on the effectiveness of one aspect of Mustard gas.

Fries, Amos A., and Clarence J. West. *Chemical Warfare*. New York: McGraw-Hill, 1921.

A book written in 1921 by the person in charge of the US CWS. Gives a biased and very detailed account about the US strategy about every aspect of gas warfare. The book also shared the ethical implications of chemical warfare through the lens of Amos Fries right after the war ended.

Garner, James W. "Some Questions of International Law in the European War." *The American Journal of International Law* 10, no. 1 (1916): 12-41.

This article examines questions of international law that arose early during WWI from the American perspective. This articles is an early reference to just war theory and discusses air raids on undefended towns, the invasion of Belgium and the rights of neutral nations, as well as the German idea that they are threatened and have no choice but to fight to win, no matter the cost.

Genders, William L. "WOODROW WILSON AND THE 'PREPAREDNESS TOUR' OF THE MIDWEST." *Australasian Journal of American Studies* 9, no. 1 (January/February 1990): 75-80.

This source explores United States President Woodrow Wilson's opinion of the preparedness of how prepared the country should be, and includes information on the opposition to those ideas.

Girard, Marion. *A Strange and Formidable Weapon: British Responses to World War I Poison Gas*. Lincoln: University of Nebraska Press, 2008.

The book is an overview of the British reaction and opinion of gas warfare. It portrays Britain as trying very hard to maintain its moral high ground during the war and then shows how Britain's opinion about gas warfare changes very shortly after the war. The book also covers how chemical warfare was represented in media and propaganda as well as the effect on the army, scientists, and industry during ww1.

Gordon, Martin K., Barry R. Sude, and Ruth Ann Overbeck. *Chemical Testing in the Great War: The American University Experiment Station.* Washington, D.C.: Historical Society of Washington, D.C., 1994.

This source discusses the U.S. chemical weapons testing facility in Washington D.C. at Catholic University. The article details the foundation of the facility as well as some of the experiments that took place. The article also mentions the role the facility played after the war.

Greenwood, John T. "The American Military Observers of the Russo-Japanese War (1904-1905)." *Army History* 36 (1996).

An official record of what the US saw as it observed the Russo Japanese war. The most relevant information is the information pertaining to the Russian use of machine guns during the conflict

Grip, Lina, and John Hart. "The Use of Chemical Weapons in the 1935–36 Italo-Ethiopian War." *SIPRI Arms Control and Non-proliferation Programmme*, October 2009.

This source gives information on what happened in the Italo-Ethiopian war regarding chemical warfare including statistics from contemporary sources. The source also gives insight about how the conflict related to the Geneva Convention and the League of Nations.

Grundmann, Siegfried, and Ann M. Hentschel. *The Einstein Dossiers: Science and Politics - Einsteins Berlin Period with an Appendix on Einsteins FBI File*. Berlin: Springer, 2010.

A book detailing sources relating to Einstein throughout his life. Includes the full text of the Manifesto to the Europeans as well as background of why it was written and why it was left unpublished.

Gullace, Nicoletta F. "Sexual Violence and Family Honor: British Propaganda and International Law during the First World War." *The American Historical Review* 102, no. 3 (June 1997).

A source that explores British propaganda during World War 1 and describes events that the Allies saw as being atrocious such as the rape of Belgium. In doing so, the book describes the German Ideology of *Kriegsraison*.

Haber, L. F. *The Poisonous Cloud: Chemical Warfare in the First World War*. Oxford: Clarendon Press, 1986.

A book written by the son of Fritz Haber about chemical warfare in the First World War The book uses information cited with German reports and letters as evidence, which is valuable for understanding the German perspective of Chemical warfare during the First World War.

Haferkorn, Henry E., and Felix Neumann. "Poisonous Gas in Warfare." *Professional Memoirs, Corps of Engineers, United States Army, and Engineer Department at Large* 9, no. 48 (1917): 758-84.

This article explains different gas treatments tested during the early months of gas warfare in 1915

Hager, Thomas. The Alchemy of Air: A Jewish Genius, a Doomed Tycoon, and the Scientific Discovery That Fed the World but Fueled the Rise of Hitler. New York: Broadway Books, 2009.

This source investigates the discovery of the Haber-Bosch process that was l to German superiority in chemical warfare During World War 1, as well as examining its influence.

Hale, George E. "From the National Research Council." *Journal of the Society of Mechanical Engineers* 39, no. 1 (1917).

This source details the founding of the National Research Council in the United States and what it means for Engineers.

Harris, Robert, and Jeremy Paxman. *A Higher Form of Killing: The Secret History of Chemical and Biological Warfare*. New York: Random House, 2002.

A source that describes the history of chemical warfare. The source uses contemporary sources to show a different perspective than was shown right after World War 1.

Hayes, Peter. "Carl Bosch and Carl Krauch: Chemistry and the Political Economy of Germany, 1925–1945." *The Journal of Economic History* 47, no. 02 (1987): 353-63. doi:10.1017/s0022050700048117.

This source examines how chemists and chemistry were treated in Germany during the interwar years.

Heller, Charles E. "Chemical Warfare in World War 1: The American Experience, 1917-1918 (Leavenworth Papers, Number 10)." September 1984. doi:10.21236/ada189331.

This source details the American preparation for chemical warfare both prior and after the entry into the war. The book also gives insight on the American Expeditionary Force's experience with gas on the western front.

Herrlich, Peter. "The Responsibility of the Scientist." *EMBO Reports* 14, no. 9 (2013): 759-64. doi:10.1038/embor.2013.116.

A source that discusses the question of whether scientists bear the responsibility for how their research is used or not. The source uses examples of scientists who are relevant.

Horne, Charles F., Walter F. Austin, and Leonard Porter Ayres. *Source Records of the Great War*. New York: National Alumni, 1923.

A source that provides primary source documents about World War 1, including a source that was the official comment of Germany after Using poison gas at the Second Battle of Ypres.

Horne, John, and Alan Kramer. *German Atrocities, 1914: A History of Denial*. New Haven, CT: Yale University Press, 2001.

A more recent book detailing the actions done at the rape of Belgium including civilian casualty estimates.

Horne, John, and Alan Kramer. "German "Atrocities" and Franco-German Opinion, 1914: The Evidence of German Soldiers Diaries." *The Journal of Modern History* 66, no. 1 (1994): 1-33. doi:10.1086/244776.

This source uses primary sources from both France and Germany to show the perspectives on the events that took place during the invasion of Belgium, explaining

how Britain had used it in its propaganda, making their perspective exaggerated, and how German sources were not always historically accurate.

Jeffreys, Diarmuid. *Hell's Cartel IG Farben and the Making of Hitler's War Machine*. Henry Holt & Co, 2010.

Talks about the German chemical industry before, during, and after the Great War. Will be useful in creating an idea of what the political and industrial climate in Germany was at the start of the war.

JENNINGS, Walter Louis. Biography from the WPI Archives,1944, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

A biography of Jennings from the WPI archives. Includes basic biographical information as well as the associations he was part of, his professional record, and his publications.

Jones, Simon, and Richard Hook. *World War I Gas Warfare Tactics and Equipment*. Oxford: Osprey Publishing, 2008.

This source discusses chemical warfare from its development to the actual implementation of a few of the more famous gases, such as chlorine, phosgene, and mustard gas. The source also discusses the impact of the gases, the production and filling of the gas shells and the dangers its posed, as well as some of the postwar conditions and treaties that were signed at the end of World War I.

Kendall, Paul. *Armistice 1918: The Last Days of The First World War Told Through Newspaper Reports, Official Documents and the Accounts of Those Who Were There*. Barnsley: Frontline Books, 2017.

A source that gives information of what happened in the final days of World War 1, and as the source uses newspaper articles, the source shows the general feelings of people living in those times.

Kevles, Daniel Jo. The Physicists: *The History of a Scientific Community in Modern America.* Cambridge, MA: Harvard University Press, 1995.

The book describes the state American chemical and military research was in prior to WWI and how it slowly developed when the Lusitania was sunk and when war was declared. The book also gives some details of the opinions of scientists about Germany's actions during the war. The source gives good context to WPI's role in chemical research in WWII.

Letter from Ira Hollis, the president of WPI to the principal of Dover High School,

November 20, 1918, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

A source found at the WPI archives that states what has happened to WPI as a result of the war as well as how it will effect admissions.

Letter from Professor Hollis to the students of WPI, September 10, 1918, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

A letter from the then current president of WPI to the students of WPI explaining the changes to the school as a result of directions from the War department. This source was part of the Archival research.

Letter from Walter L. Jennings to WPI President Hollis,April 9 ,1920, A17903 425998, Box UA009:045, Folder UA009:2268, WWI and WPI fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

A Letter in the WPI Archives from Jennings to President Hollis that details a request from the National Research Council about the amount of funds spent on research at WPI.

Macdonald, Lyn. *1915, the Death of Innocence*. Baltimore: Johns Hopkins University Press, 2000.

A record of the major events British soldiers experienced during 1915, including Gallipoli and the Second Battle of Ypres. The source combines narration along with primary sources and accounts to describe the events and their immediate impact on troops.

MacDonald, Lyn. *They Called It Passchendaele*. 1979.

This source details the preparations taken by the British before the offensive at Passchendaele as well as the events and sub-battles during the offensive. The source blends narration and primary accounts in order to describe the experiences and mood of the soldiers who participate in the offensive.

Malinowski, Bronislaw. "An Anthropological Analysis of War." *American Journal of Sociology* 46, no. 4 (1941): 521-50.

This article examines primitive cultures and recounts how war is waged even though there are no “rules” to warfare in these regions. The article also relates war to human behaviors, such as humans’ need for food or to defend against attackers, and argues these same principles apply to the state, which uses war as a tool for survival.

Manisty, Herbert F. "The Use of Poison Gas in War." Transactions of the Grotius Society 9 (1923): 17-28.

A source that includes firsthand accounts of soldiers on the battlefield getting gassed as well as approaching the gas situation from a legal perspective in the context of international law.

McCrae, John. *In Flanders Fields*. Ottawa: Union Government Publicity Bureau, 1917.

A well-known and often quoted poem written in World War about the experience of a soldier fighting in the trenches.

Nicholson, Rafaelle M., and John W. Nicholson. "Martha Whiteley of Imperial College, London: A Pioneering Woman Chemist." *Journal of Chemical Education* 89, no. 5 (2012): 598-601. doi:10.1021/ed2005455.

A journal article written about Martha Whiteley and her work done during the war. She was an influential military research chemist for Britain during the war, and thus gives insight on chemical warfare research in Britain.

Norman, Richard. *Ethics, Killing and War*. Cambridge: Cambridge Univ. Press, 1999.

This book argues whether it is justifiable and under what circumstances humans can be killed and expounds this argument to include wars and nations. The author uses a quantitative approach to the idea of killing, arguing the value one is saving must be greater than the value of the person being killed. This book is an alternative to just war theory and focuses on the killing of humans, as opposed to the conduct or motives of a war.

Obituary of Dr. W. L. Jennings in an unknown newspaper ,September 2, 1944, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

This source is a newspaper article from the WPI Archives that is an Obituary for Jennings that describes some of his accomplishments, including his accomplishments during World War 1.

Palmer, Frederick. *Newton D. Baker ; America at War: Based on the Personal Papers of the Secretary of War in the World War ; His Correspondence with the President and Important Leaders at Home and Abroad*. New York: Dodd, Mead, 1931.

A book written in 1931 that tries to depict what was actually going on internally in the government during the First World War. The source sources documents relating to the secretary of war and gives insight into topics such as allied propaganda.

Paret, Peter, and Michael Walzer. "Just and Unjust Wars: A Moral Argument with Historical Illustrations." *The American Historical Review* 83, no. 5 (1978): 1228. doi:10.2307/1854700.

While not about chemical warfare, this book gives a fair overview of what constitutes a just war. We can use these analyses to see how chemical warfare would be a just means to fight. It mainly discusses what gives you the right to declare war and about how weapons or actions against innocent civilians is unjust. It also brings in ethical frameworks to consider, e.g. Utilitarianism.

Pegler, Martin. The Vickers-Maxim Machine Gun. Oxford: Osprey Publishing, 2013.
Willmott, Hedley Paul. *World War I*. DK, 2003

This source provides an overview of key events and battles during World War I. The source chronologically details events on the battlefields across multiple fronts, such as the Western, Eastern and African fronts, as well as events beyond the battlefield, such as the roll the home front played during the war.

Prentiss, Augustin M., and George J. B. Fisher. *Chemicals in War: A Treatise on Chemical Warfare*. New York: McGraw-Hill Book, 1937.

A comprehensive account of the history of chemical warfare written by an American during the interwar period. The source includes gas warfare statistics as well as how they were calculated, as well as an analysis of whether chemical weapons were effective.

Preston, Diana. *A Higher Form of Killing: Six Weeks in World War I That Changed the Nature of Warfare.* London: Bloomsbury Press, 2016.

Although it is not a good source on specific details, it brings up interesting ideas about weapons of mass destruction and the law of war. The book brings up the examples of bombings, gas, and submarines and the consequences of technology on civilians during war. Brings up points like why certain other banned weapons were not used and similarities to bombing.

Price, Richard M. *The Chemical Weapons Taboo*. Ithaca, NY: Cornell Paperbacks, 2007.

A book that describes the taboo of chemical warfare over time to the present. The source has a large amount of information about how gas was used and perceived in the interwar years.

Professors of Germany. "To the Civilized World." *The North American Review* 210, no. 765 (August 1919): 284-87.Translated By University of Northern Iowa.

An English translation of what is commonly referred to as the Manifesto of the Ninety-Three. Includes the scientists who signed the document and what kind of academic they were.

Quigley, Leon V. "American Contemporaries ,Walter Louis Jennings." *Industrial & Engineering Chemistry* 23, no. 2 (1931): 244-45.

A journal article that was found in the archives that details the accomplishments of Professor Jennings, including his achievements During World War 1.

Roosevelt, Theodore. *America and the World War*. New York: Charles Scribner, 1915.

A book written by an US President that was not in office during World War 1. The source gives a unique perspective as well as the advantage of insight to the documents and workings of the US government.

Roy, Kaushik. *Hinduism and the Ethics of Warfare in South Asia: From Antiquity to the Present*. Cambridge: Cambridge University Press, 2012.

This book talks about Just War in ancient India. Useful for understanding Just War theory throughout history from a perspective outside of just Europe.

Ryan, T. Anthony. Phosgene and Related Carbonyl Halides. Amsterdam: Elsevier, 1996.

This source is a comprehensive history on phosgene from its discovery to modern use. The source also goes into great detail about its use as chemical warfare agent as well compiling statistics on the effectiveness of the gas and why the methods for attaining those statistics were flawed.

Scott, James Brown. *The Hague Conventions and Declarations of 1899 and 1907: Accompanied by Tables of Signatures, Ratifications and Adhesions of the Various Powers and Texts Reservations*. New York, 1915.

A 1915 book that includes the full text of the Hague Conventions, the countries that attended, which countries ratified which sections, and comparisons between the 1899 conference and the 1907 conference. The book also includes the initial letters that were sent to different countries that led to the conference happening.

Scott, James Brown. *The Hague Peace Conferences of 1899 and 1907. A Series of Lectures Delivered before the Johns Hopkins University in the Year 1908*. Baltimore: Johns Hopkins Press, 1909.

A detailed book written about the Hague Conference before World War I started. The book goes into detail about the background of the conventions and the various discussions that happened relating to many of the sections of them.

Slotten, Hugh R. "Humane Chemistry or Scientific Barbarism? American Responses to World War I Poison Gas, 1915-1930." *The Journal of American History* 77, no. 2 (1990): 476-98.

This article examines the debate about the humanity of gas warfare and the opposing views of the British, Germans, and Americans. The primary focus of the article is the views and opinions of Americans, who initially were able to view gas warfare from the outside, before entering the war, during the war, and after the war.

Smith, Susan L. *Toxic Exposures: Mustard Gas and the Health Consequences of World War II in the United States.* New Brunswick, New Jersey: Rutgers University Press, 2017.

The book investigates the long term effects and consequences of the use of mustard gas mostly after ww1. It does present some information and parallels to ww1. The main sections of the book are related to the testing on US soldiers and the ethical concerns, racial testing, dumping in the sea, and mustard gas use for chemotherapy.

Spear, Ellwood B. "Some Problems of Gas Warfare." *The Scientific Monthly* 8, no. 3 (1919): 257-83.

A 1919 source that describes some of the problems with Chemical warfare that the militaries faced. Includes information on gas shells, but focuses on gas masks and their effect to the battlefield.

"Special Cable to THE NEW YORK TIMES.BELGIUM'S CASE TO THE WORLD." New York Times, October 6, 1914.

New York Times article that states Belgian's message to the rest of the world about what happened during the invasion of Belgium.

Stevens, Lester. "Interview with Lester Stevens: 8th Battalion." Interview by Frank Lalor. *Flanders Fields*. Canadian Broadcasting Corporation. 1964.

An interview with a World War 1 veteran about their experiences in the trenches done by the Canadian Broadcasting Corporation.

Stevenson, D. *1914-1918: The History of the First World War*. London: Allen Lane, 2004.

A book that gives a more broad and general overview of World War 1 events. Useful for finding the days of battles as well as casualty numbers.

Strachan, Hew. "The 2010 George C. Marshall Lecture in Military History: Clausewitz and the First World War." *Journal of Military History* 75, no. 2 (April 2011): 367-91.

A journal article written by a author that has many works on Clausewitz. The journal article goes into detail about why Clausewitz was significant and his impact on the First World War

"Telegram from Frank Polk to the American Embassy in Mexico City." Frank Frank Polk to American Embassy in Mexico City. February 26, 1917. General Records of the Department of State.

The telegram that the US sent after news of the Zimmerman telegram was discovered in the US. This source provides insight into the American feelings about the situation and includes valuable quotes

"The After-Effects Of Gas Poisoning." *The British Medical Journal* 1, no. 3045 (1919): 586.

This article details some of the effects of gas warfare just before the Treaty of Versailles was signed. The article maintains an extremely positive view, believing few soldiers who were gassed will be permanently affected or disabled.

"THE DOUBLE WAR OF CHLORINE IN WAR." *The Boston Medical and Surgical Journal* 173 (July 1, 1915): 23-24.

This source was an American journal that claimed that chlorine gas was nefarious, that chlorine was found on German corpses. The source did not specifically condemn the Germans.

"The German Use Of Asphyxiating Gases." *The British Medical Journal* 1, no. 2835 (1915): 774-75.

This article describes the immediate aftermath of the gas attack at Ypres. The article also describes the gas masks that must be provided to the soldiers as soon as possible.

The Tech News.Worcester Polytechnic Institute. Vol. 6-10.

This source is a weekly student newspaper during the academic year, of which the journals used span September 15, 1914, to June 17, 1919. It includes information about events and assemblies that happened and will happen on campus.

The Journal of the Worcester Polytechnic Institute 18-22 (November 1914-1919).

A Journal published by WPI that contains articles published at WPI, proceedings of events that occured on campus, and statistics about the student body.

Trumpener, Ulrich. "The Road to Ypres: The Beginnings of Gas Warfare in World War I." *The Journal of Modern History* 47, no. 3 (1975): 460-80. doi:10.1086/241340

This journal focuses on early chemical warfare during World War I using many German sources. The source starts with an extensive amount of information relating to the use of tear gases, then goes into the use of chlorine in detail, and finishes with referencing phosgene.

Turns, David. "Military Necessity." *Oxford Bibliographies Online Datasets*, 2012. doi:10.1093/obo/9780199796953-0008.

A source that details different viewpoints on military necessity in different periods of history. The source provides primary documents relating to military necessity, and investigates *Kriegsraison*.

Niemeyer, Theodor. "International Law in War." *Michigan Law Review* 13, no. 3 (1915): 175-78.

This article discusses the importance and power of international treaties and international law and whether or not these treaties may be enforced during war. The central point in the article is the invasion of Belgium and whether or not something such as neutrality guaranteed by treaty can be upheld during war.

Tolstoy, Leo. "Count Tolstoy on the Russo-Japanese War." *The Advocate of Peace* 66, no. 9 (1904): 164-76.

This article discussed Leo Tolstoy's opinions of the Russo-Japanese War, namely the morally degradation in the world and how people openly and willingly supported murdering millions of people. Tolstoy also warns the potential impacts of new, more powerful weapons which could spell doom for humanity.

Tucker, Jonathan B. *War of Nerves: Chemical Warfare from World War I to Al-Qaeda*. New York, NY: Anchor Books, 2007.

The book give an early history of gas warfare, early quotes of why gas warfare was unethical, some info of why gas warfare was used by Germany, how the allies felt about mustard gas, and the damage of mustard gas to civilians.

UK Parliament. "Sir Edward Grey's Speech before the House of Commons." *Parliamentary Debates, Commons*, 5th ser., 65 (1914): 1809ff.

A speech by Sir Edward Grey about the invasion of Belgium. The source was from the UK parliament archive and includes information about under what circumstances Britain would declare war on Germany.

US Department of State. *Papers Relating to the Foreign Relations of the United States: 1919: The Paris Peace Conference*. Vol. IV. Washington: Department of State Printing Office, 1942.

This source is the official US history of its role in the treaty of Versailles. Includes what happened during every meeting that the United States took part in, including quotes and members present at the meetings.

Uprichard, John. "Interview with John Uprichard: 8th Battalion." Interview by Frank Lalor. *Flanders Fields*. Canadian Broadcasting Corporation. 1964.

An interview with a World War 1 veteran about their experiences in the trenches done by the Canadian Broadcasting Corporation.

Vilensky, Joel A., and Pandy R. Sinish. *Dew of Death: The Story of Lewisite, Americas World War I Weapon of Mass Destruction*. Bloomington, IN: Indiana University Press, 2005.

This book explores the development and history of lewisite in the United States, gives motives of scientists to work on the project, and gives a general insight of the US's view on chemical warfare. The book also gives quotes from the creator of lewisite on why gas warfare is not unethical.

Von Elbe, Joachim. "The Evolution of the Concept of the Just War in International Law." *The American Journal of International Law* 33, no. 4 (1939): 665-88. doi:10.2307/2192879.

This article details the evolution of just war theory from the early days of Plato and Aristotle, to Grotius and other medieval thinkers. The general idea of just war theory from the perspective of these thinkers is wars must be defensive in nature and must seek to establish peace and harmony.

Wachtel, Curt. *Chemical Warfare*. Brooklyn, NY: Chemical Publishing Comp., 1941.

This book briefly details the author's involvement in the chemical industry during WWI as well as his experiences meeting with other chemical researchers after the war inRussia, France and England. This book also details different groups and types of chemical weapons as well as the impact and criteria for creating and testing new chemical weapons.

Wiest, Andrew A. *The Illustrated History of World War I*. London: Amber, 2014.

This source provides an overview of the major events and figures that helped shape the First World War. The source includes descriptions of the major battles, such as Verdun and the Somme, as well as events beyond the battlefield, such as the sinking of the Lusitania.

Woolsey, Theodore S. "RETALIATION AND PUNISHMENT." *Proceedings of the American Society of International Law at Its Annual Meeting (1907-1917)* 9 (1915): 62-69.

This article discusses the breaches in international law that have occurred since the outbreak of WWI. The article also briefly examines the German doctrine of *Kriegsraison* and the treatment of prisoners of war and tries to explain who should be punished for the breaches in international law and how they should be punished.

WPI Alumni Association Biographical Records of Walter Louis Jennings, A17903 426009, Box UA009.046, Folder UA009.2291, UA009 Faculty - Jennings, Walter Louis fonds, Worcester Polytechnic Institute Gordon Library Archives, Worcester, Massachusetts, U.S.

The WPI Alumni Association biography of Professor Jennings found in the WPI archives. Includes information on the honor societies he was in, the organizations he was part of,etc.

"Zimmermann Telegram." Robert Lansing to Walter Page. February 24, 1917. General Records of the Department of State.

The original British telegram to the United States Secretary of State detailing the contents of the Zimmerman Telegram.