**The Father of Chemical Warfare**

***Fritz Haber could have been remembered as one of the greatest figures in the history of science; instead, he is remembered as its greatest villain.***

On 22 April 1915, soldiers in the Allied lines outside Ypres saw a strange phenomenon creep toward them. Drifting across No Man’s Land, caught in a light breeze away from the German lines, was a rolling sea of yellow-green cloud. Heavier than air, the lime mist moved at little more than walking pace. To avoid the strange weather, all the French troops in the trenches, mostly men from Algeria and Martinique, needed to do was run. And yet, to a man, they stayed where they were. They’d never seen anything like it. They didn’t know what would happen. They didn’t know they would die.

The men were staring at 168 tonnes of chlorine gas, seeping out from 5730 canisters positioned along a mile-long section of the front. In moments, the men began to choke and wheeze as the gas scorched their lungs, turning to hydrochloric acid that melted tissues and flooded airways. Some men drowned in their own mucus; others were said to have literally coughed their lungs out. In 10 minutes, up to 5000 men were dead and a further 10,000 injured as the Allied line collapsed and a four-mile hole in the front emerged. As one of the British soldiers behind the lines later wrote: “Here staggered into our midst French soldiers, blinded, coughing, chests heaving, faces an ugly purple colour, lips speechless with agony, and behind them in the gas-soaked trenches, we learned that they had left hundreds of dead and dying comrades.”

The age of weapons of mass destruction had begun. By the end of the first world war, chemical attack would lead to 1.2 million casualties and around 100,000 dead.

In the German trenches, the mastermind of the attack watched the results. Short, fat and bald, wearing a fur coat and smoking a cigar, Captain Fritz Haber did not look like the classic Prussian junker. It was a fair assessment; he was the head of the chemistry section at the Germany Ministry of War, and his only prior military experience was a year’s voluntary service with a field artillery unit in 1889. In fact, before the war, he had a burgeoning reputation as one of the world’s great humanitarians.

**Bread from the Air**

Haber was born in Breslau, Prussia in 1868 to wealthy Jewish merchants. Initially, he had joined the family dye business as a chemist, but after falling out with his father he became an academic, working in Germany and Switzerland before eventually progressing to the University of Karlsruhe. Here, he focused on preventing the loss of energy from engines and turbines, and studying the flames of Bunsen burners. But in 1905, while writing a book on thermodynamics, he made the greatest scientific breakthrough of his career: at high temperatures, and with a little iron as a catalyst, he could make ammonia from nitrogen and oxygen.

Ammonia is an important chemical, as it can be used as a building block in the manufacture of fertilizers and explosives. At the time, the world’s supply of nitrates came from guano, bird poo, and was dominated by South America, particularly around the Atacama desert in Chile. The need for guano was so acute that multiple wars had been fought for the resource, including the Chincha Islands war between Spain and its former south American colonies, and the war of the Pacific between Chile, Bolivia and Peru. The United States had even passed its Guano Islands Act in 1856, allowing any US citizen to claim an island for the country if a bird had done its business on the rocks. (To this day, many of the US’ overseas possessions are a result of the Act – most famously Midway Atoll in the Pacific.)

Haber’s discovery would break the guano monopoly. In a series of experiments, with aid of Carl Bosch and the British chemist Robert Le Rossignol, Haber was able to create ammonia from nitrogen in the atmosphere, using a series of high-temperature, high-pressure reactions and a metal catalyst. The discovery was sold to BASF, and in 1913, the first industrial fertilizer plant using the ‘Haber process’ came online. It proved an immediate success: suddenly, the world did not have to rely on guano for nitrates, and millions who would otherwise have died of famine had food in their bellies. Haber’s discovery was heralded as ‘bread from the air’. Today, the Haber process is responsible for around 50% of nitrogen in our bodies, and is one of the main factors for the 20th century’s population explosion to almost 8 billion people.

The Haber process also became Germany’s first secret weapon of the great war. In 1914, the Allies immediately used their sea power and company monopolies to create an effective blockade of saltpetre coming from the Chilean guano mines. The move could have brought an early end to the war; without saltpetre, the Central Powers wouldn’t have been able to produce the nitric acid desperately needed for munitions. Instead, the Haber process allowed Germany to continue to supply its forces with the ammunition needed to fight.

Haber had, almost single-handedly, prevented the early defeat of the Central Powers. And yet his contribution was far from over. It would prove to be one of the most controversial in history – and come at great personal cost.

**An Evolution of Combat**

Haber’s attack at Ypres in April 1915 wasn’t the first use of chemical weapons in history; nor was it the first attack in the war. In August 1914, the French had launched tear gas at German positions; in October that year the Germans had done the same in return. In January 1915, the Germans had again tried tear gas at the Battle of Bolimov, only for the liquid to freeze in its canisters instead of dispersing as a gas. But Haber decided to take chemical warfare to a new, and fatal, level.

Haber’s motivation was simple: a deep sense of patriotic duty. Always conscious of his Jewish heritage, Haber had already converted to Lutheranism to distance himself from the religion and portray himself as a German first. Now, with his country engulfed in war, he became obsessed with proving his loyalty, arguing that “during peacetime a scientist belongs to the world; but during war time he belongs to his country”. As director of the Kaiser Wilhelm Institute for Physical Chemistry, he had given the laboratory entirely over to the war effort, and in October 1914, he, along with other prominent academics and intellectuals, had signed the Manifesto of the Ninety-Three. This pledged full support for the Central Powers, including the insistence the war had been forced on Germany, and their country had not invaded Belgium while it was neutral. Notably, it also stated: “It is not true our warfare pays no respect to international laws. It knows no undisciplined cruelty.”

By then, Haber was already preparing a move that would break two international treaties and go against his own statements. Both the Hague Conventions of 1899 and 1907 banned the use of chemical weapons in war, specifically the “use of projectiles the sole objective of which is the diffusion of asphyxiating or deleterious gases”. But, Haber reasoned, the French had done it first.

Preparations for a chemical attack began in early 1915, with two units – Pioneer Regiments 35 and 36 – established to oversee gas dispersal. Rather than trust this to untrained troops, Haber recruited up-and-coming stars of science. Among them were three future Nobel prize winners: physicists James Franck and Gustav Hertz (who would win the prize together after the war), and Otto Hahn, a chemist and distinguished soldier who had won an Iron Cross second class at the first battle of Ypres in 1914. Under Haber’s instruction, the trio scouted for the ideal place to use their new weapon.

Chlorine was not difficult to source: it was widely used in the dye industry Haber had grown up with, and was readily available in the industrial quantities needed for his plan. Haber’s intent was to rapidly break through the Allied lines, allowing a German advance that would end the war in a single blow. Chemical warfare, he reasoned, was not horrific; rather, it was the equivalent of knights suddenly facing firearms – an evolution of combat. More importantly, he staunchly believed his innovation would save lives. “The aversion that is fed by the strangeness of the weapon is further enhanced by the imagination,” Haber told officers of the Reichswehr, the German Ministry of Defence, in 1920. “Gas as a weapon is not crueller than flying pieces of metal. To the contrary, the partition of fatal diseases is comparably small.”

Haber had been exposed to gas and survived. This bolstered his belief that, unlike those hit by an artillery shell or a bullet, most gas casualties would recover completely. In addition to being more humane than machine gun fire, Haber also reasoned that the terror caused by chemical weapons would see men to break and run much earlier, making battles shorter. “With every change in the impression that the nose and mouth are feeling,” he continued, “the soul is trembled by a new and unknown impact. It is a new challenge to the moral strength of the soldier when the whole performance of his soul is needed for the fight.”

The attack at Ypres had exactly that effect – on his own troops as well as the French. Rather than storm through the Allied trenches, the Germans were unwilling to advance for risk of harm themselves. Within a day, the Allies had bolstered the front line, and made makeshift gas masks to counter the threat. Far from ending the war, chemical weapons only prolonged it. Haber’s great breakthrough never happened, and he returned to Berlin to further develop his poisons.

**Perversions of Science**

It was not a happy homecoming. In 1901 Haber had married Clara Immerwahr, the first woman to be awarded a chemistry PhD in Germany. As a mother, Clara was expected to stay at home, but still often worked with her husband on his chemical breakthroughs. And yet Haber’s determination to use her beloved science as a weapon outraged her. It was, she wrote, “a perversion of the ideals of science … a sign of barbarity, corrupting the very discipline which ought to bring new insights to life.”

On 1 May 1915, shortly after Haber’s return from the front, Clara sat down at her desk and wrote farewell letters to her friends and family. She then walked out into the garden with Haber's service pistol, fired a test shot, and killed herself. The suicide letters did not survive, and so her motivations are still unknown; Clara had been suffering from depression, and hated the limitations society imposed because of her gender. Even so, it’s hard to imagine her husband’s use of poison gas was not a factor in her death.

Haber was overcome by grief. The next day, he was required to leave home to oversee a second chemical weapon attack, this time on the eastern front. “Every next day of bullets whizzing past is good for me,” he wrote in his diary. “Here, only the present counts … but when I get back to the staff office, clinging to the telephone receiver, I can still hear in my heart the words she once told me. Exhausted, I can see her head appearing amid orders and telegrams, and it gives me pain.”

As Haber mourned the death of Clara, the Allies were preparing their own chemical attacks. On 23 April, the day after the attack at Ypres, Sir John French, the commander of the British Expeditionary Force, had telegraphed London: “Urge that immediate steps be taken to supply similar means of most effective kind for use by our troops.” The first world war had become an arms race between scientists.

**The Chemist’s War**

In the next four years, around 190,000 tonnes of chemical weapons were produced by both sides. By far the deadliest, responsible for around 85% of deaths due to gas attacks in the war, was phosgene. This was the brainchild of the French chemist Victor Grignard, a Nobel prize winner who, as a 43-year-old professor, had been conscripted to the French army as a corporal. Over the next few years, he would become Haber’s chief opponent in the race to develop more effective chemical assaults, as France militarised 16 medical schools and the University of Paris to coordinate the research. Ultimately, no combatant could afford to ignore the weapon; even the Americans, who only arrived en masse in 1918, began to develop their own ‘Gas and Flame’ division and eventually its Chemical Warfare Service, staffed by officers recruited from major league baseball including future hall-of-famers Ty Cobb, Branch Rickey and Christy Mathewson (the latter of whom would die soon after of complications from inhaling the gas).

Yet Haber’s name remained the most attached to this new form of warfare. He began to split his time between producing new chemical weapons and developing effective gas masks to defend against Grignard’s efforts. Gradually, Haber became further integrated into German strategic planning. Technically an adviser, he found himself hugely influential in both the production and use of his new weapon. Later, he recalled that he was “one of the mightiest men in Germany. I was more than a great army commander, more than a captain of industry. I was the founder of industries.”

On the front, gas attacks became more brutal and, as Haber predicted, the most feared weapon. Perhaps the best example of its effects occurred on 6 August 1915, when the Russian defenders of Osoweisc Fortress were bombarded by chlorine and bromine. Somehow, despite their faces smothered in their own blood and phlegm, the Russian survivors mustered a counter-attack, sending the terrified German soldiers into retreat. The terrifying appearance of the Russians led to the battle being named the Attack of the Dead Men.

Gas tactics didn’t remain static throughout the war – as with almost every aspect of military research, they evolved as both sides gained experience. Gas masks evolved from urea-soaked rags to advanced respirators, often tested by Haber’s men personally; eventually this included masks for horses, dogs and even carrier pigeons. Deployment of gas became an artform, using meteorology, the stability of the agent and a host of artillery shells, mortars, and mines to deliver it to best effect. By 1917, the dangers of inhaling gas had largely been countered, and so the Germans tried a new weapon, LOST, named after the two scientists, Wilhelm Lommel and Wilhelm Steinkopf, who developed it. The gas was a vesicant, and rendered gas masks useless – rather than needing to be inhaled, it caused blisters on any skin that came into contact with it. Soon, it became known by the family of sulfur-based compounds it stemmed from: mustard gas. By the war’s end, with the use of mustard gas embraced by both sides, it had accounted for more casualties (though comparatively fewer fatalities) than the rest of the chemical weapons combined.

Haber’s troops had varying fates throughout the war. Hahn again showed his bravery at the Battle of Bolimów in June 1915, where he personally led the advance after a gas attack, even stopping to help injured Russian troops after the breakthrough. In 1917, disguised in an Austro-Hungarian uniform, he led the use of *minenwerfer* chemical mortars against Italian troops. He was later poisoned by phosgene while testing a new gas mask design, but survived and ended the war developing arsenic-based bombs. Hertz also fought at Bolimów, but was poisoned by his own creation in July 1915 when the gas blew back into the German lines, and returned to academia two years later. Franck, meanwhile, worked with Haber on the design of gas masks, and was eventually awarded the Iron Cross, first class, for his efforts in February 1918.

As the war ended, Haber found himself on the losing side. And while figures such as Grignard were rapidly rehabilitated by the scientific establishment, the Allies found Haber’s support for chemical weapons unforgivable. His Haber process spread around the world, saving billions of lives, but as the ‘father of chemical warfare’ his reputation was tainted forever.

**A Higher Form of Killing**

Haber remained unrepentant about his military service, and became a staunch defender of chemical agents. In April 1919, he wrote to fellow chemist Carl Duisberg that before him war had been nothing more than a game of chequers, played with artillery, and that it had “turned to chess with poisoned gas warfare and the defence against it”. Later that year, when his work on the Haber process won him the Nobel prize, he was lauded by Åke Ekstrand, the President of the Royal Swedish Academy of Sciences, who proclaimed “we congratulate you on this triumph in the service of your country and the whole of humanity.” True to form, Haber chose to focus on his other passion during his acceptance speech. “In no future war,” he told the shocked crowd, “will the military be able to ignore poison gas. It is a higher form of killing.”

Throughout the 1920s, Haber continued his study of chemical weapons, turning his attention to pesticides – one of which would later be developed into Zyklon B, used by Nazi Germany in the Holocaust. Haber opposed to the rise of national socialism, and became horrified at the expulsion of Jews from academic positions – which, despite his conversion decades earlier, included himself. In early 1933, he arrived for work at the Kaiser Wilhelm Institute and was told that “the Jew Haber is not allowed in here”. He had no choice other than to resign.

Haber didn’t know where to go. He travelled to France, Spain and Switzerland, his health failing rapidly. He settled in Cambridge for a few months, but the British scientists proved openly hostile, unable to forgive him for his actions two decades earlier; Ernest Rutherford, then the foremost scientist in the world, refused to shake his hand. Broken, Haber accepted a position in Palestine, and began to travel across Europe. He never arrived. On 29 January 1934, he died in a hotel room in Basel, Switzerland.

Haber’s vision of chemical weapons becoming the next stage in warfare was never realised. The second world war did not see the mass use of chemical agents in combat, and use of such attacks in subsequent conflicts throughout the 20th century saw instant international condemnation. In 2013, the Organization for the Prohibition of Chemical Weapons won the Nobel peace prize, with the committee declaring it had shown how chemical attacks had “become taboo under international law”. In an unlikely twist, one of his gases actually became a source of good. In 1919, researchers at the University of Pennsylvania noticed that soldiers who had died of mustard gas had unusually high white cell counts. After further research during the second world war, doctors began to experiment with a treatment based on the weapon to treat cancer patients. The result was the drug mustine, and the dawn of chemotherapy.

Instead, the weapon of mass destruction that would define the next century of warfare came from Haber’s one-time subordinate, Otto Hahn. In 1938, working with Fritz Strassmann, he obtained some strange lab results; sending them to his long-time colleague Lise Meitner, it became apparent the team had discovered nuclear fission. It was the breakthrough that would lead to nuclear power – and pave the way for the atomic bomb. In a twist of fate, Haber’s other protégés would also end up working on nuclear weapons during the second world war; James Franck joined the US Manhattan Project as the head of its chemistry division in Chicago, while Gustav Hertz surrendered to the Russians and was forced to join the Soviet nuclear effort. Thus the three stars Haber recruited in 1915 would all play a key role in creating a weapon more devastating than their mentor could have imagined.

Unlike Haber, Hahn was not proud of his creation. After the defeat of Nazi Germany, he and several other German scientists working in nuclear research had been captured by the British and interred at Farm Hall, just outside Godmanchester, Cambridgeshire. When Hahn heard atomic weapons had been used on Hiroshima and Nagasaki in Japan, he became so distraught the other prisoners kept watch on him, afraid he would attempt suicide. Four months later, still a prisoner in Britain, he learned in the *Daily Telegraph* his discovery of nuclear fission had won the Nobel prize in chemistry.

Hahn dedicated the rest of his life to being an advocate for peace and the responsible use of science. In 1955, he gathered signatures from other Nobel laureates highlighting the dangers of atomic bombs; two years later he successfully protested against the West German armed forces developing their own nuclear weapons. He died in 1968, having achieved the national respect that Haber had always craved, yet never received.