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# Science and Technology (USA)

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**The United States entered the First World War unprepared to deploy its army on chemical-laden battlefields. Although the first use of chemicals occurred in 1915, U.S. observers and diplomats had limited understanding of the extent to which the warring parties were using chemical weapons. As a consequence, the military made no pre-war preparations for chemicals in combat. The U.S had no domestically produced gas masks until the end of the conflict, no chemical shells, and very few delivery systems. The U.S therefore had to depend on Allied help as its leadership struggled to overcome its lack of preparedness.**

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## Introduction

The United States was unprepared for chemical warfare when it entered the Great War in 1917.[1]

Although observer reports and news media reached the U.S. War Department, no serious effort was made to prepare the military for a chemical environment in combat. In April 1917, just prior to the U.S. declaration of war, the U.S. army began to prepare for a European conflict. The Americans initially relied on Great Britain and France for instructors, doctrine, defensive equipment, artillery shells, mortars (British Stokes Mortars) and Livens Projectors (large cylindrical tubes buried in the earth, firing sisty-pound gas loaded projectiles). The U.S. army even copied British field manuals for use in the American Expeditionary Forces (AEF). President Woodrow Wilson's (1856-1924) insistence that the US not undertake significant preparations for offensive war in order to maintain neutrality partly explains this lag. However, the lack of preparedness was also due to the fact that the military had convinced itself that such weapons would be irrelevant in war, since countermeasures prior to 1917 seemed to lessen the danger of gas.

## Domestic and Civilian Research and Preparations

One government agency of the executive branch recognized the possibility of U.S. military forces being placed unprepared on chemical battlefields early on. In February 1917, the U.S. Bureau of Mines Department of the Interior initiated a study on defending against chemical weapons. Secretary of the Interior Franklin Lane (1864-1921) encouraged the National Research Council's Military Committee to study noxious gases in war. A subcommittee researched chemicals for both offensive and defensive measures. Bureau of Mines Director Van H. Manning (1861-1932) ordered an investigation by its Mine and Natural Gas Department, and the War Department assigned ordnance and medical officers to assist in the research.[2]

On 7 April 1917 work began to create a vast civilian research network in coordination with universities. American University's (Washington, D.C.) Experiment Station was selected as the location for the headquarters and laboratory, which later became the Chemical Warfare Service's (CWS) Research Division. Manning selected a Bureau chemical consultant, George A. Burrell (1882-1957), to supervise the creation of the new research network. In addition to Bureau personnel he added a representative of the American Sheet and Tin Plate Company, chemical engineering professor Warren K. Lewis (1882-1975) at the Massachusetts Institute of Technology, and Yale University Professor of Physiology Yandell Henderson (1873-1944). Several other universities and institutes responded with offers to assist, including the Johns Hopkins University and the Mellon Institution.[3] Another Bureau member was directed to network with laboratories at other universities. Laboratories were established in twenty-one universities, three chemical companies, and three government facilities, with a total of 118 chemists. By December 1917 the Bureau of Mines staff working on chemical warfare had increased to 227 civilians and 234 military personnel.[4]

In addition to the Bureau of Mines, the Army Medical Department also began to research defensive equipment and how to treat chemical casualties. Professor Henderson was responsible for medical research. Still the Bureau had limited capabilities and requested assistance from universities. With no space available in Washington, Yale University agreed to use its Athletic Club as a laboratory. In order to make this possible the administration built an additional laboratory under the playing fields' bleachers. Yale faculty, medical school students and Bureau of Mine personnel conducted research in chemical toxicology.

## Military Preparations

The Ordnance Department was responsible for the offensive use of chemicals and assigned gas and shell procurement to its Trench Warfare Section. Several months later the Ordnance Chief, Major General William Crozier (1855-1942), approved a facility for the exclusive purpose of filling artillery shells with chemical agents. Gunpowder Neck (Edgewood Arsenal in Maryland) was selected as a site for government chemical production. Additionally, contracts were finally signed with private chemical companies, including Dow Chemical, General Electric, American Can Company and B.F. Goodrich Company.[5]

The Medical Department assigned defensive training to its Sanitary Corps and established a "Gas Defensive School" at Fort Sill, Oklahoma. The most important piece of chemical warfare equipment was the gas mask. Prior to the U.S. entry into the war, the Medical Department had made little progress with gas mask research. Once the U.S. entered the war the War Department sought help from civilian chemists. The Medical Department, in cooperation with the Department of Agriculture, the University of California, Princeton University, Wesleyan University, and the Carnegie Institute researched a more effective mask. The Medical Department received orders to procure an initial 25,000 masks to equip the first American division deployed to France. The B.F Goodrich Company made the face piece, but unfortunately, the variation of the British Small Box Respirator (SBR) produced by the firm failed tests conducted by the British. As a consequence the newly formed AEF ordered 600,000 masks from British sources and 100,000 M-2 French masks.

However, there was still a role for private American companies to play. The Hero Manufacturing Company assembled components for various masks. Given the urgent need, a Gas Offensive Production Division was established to assemble British and French designed masks at a manufacturing facility in Long Island City, New York. The plant was run by a "dollar a year man" (a volunteer businessman who accepted a dollar a year for his service) with a lieutenant colonel as his deputy. By November 1918 the work force had grown to 12,000 workers.[6]

The U.S. army established the Gas Defense Service, which was comprised of three sections: field supply, overseas repair, and training. The Service produced several War Department publications such as *Notes on Gas as a Weapon in Modern War* and a *Memorandum on Gas Poisoning*, both taken from French and British sources. With the deployment of an infantry division to France, the Army War College requested that British gas officers and NCOs (non-commissioned officers) be assigned to each training site in the United States. Major Samuel James Manson Auld (1884-?), Special Brigade (offensive gas unit), Royal Engineers with a detachment of officers, and NCOs reported to the Sanitary Corps. Major Auld filled the U.S. Army's doctrinal gap by preparing "a working textbook on gas” warfare. Four pamphlets were published as Adjutant General Document 705, Gas Warfare. In order of importance for soldiers in combat:

Part 3: Methods of Training in Defensive Methods

Part 2: Methods of Defense against Attack

Part 1: German Methods of Offense

Part 4: The Offense in Gas Warfare- Cloud and Projector[7]

Major Auld suggested a structure for an American Gas Service, which would mirror the British recommendations that the Army General Staff accepted. It was also decided that only combat organizations would be in charge of the emerging Gas Service. The mission held by the Sanitary Corps passed temporarily to the Corps of Engineers.

The Army Staff decided to expand the number of training sites to thirty-six to provide for a force that would grow to over 3 million. A central Army Gas School specifically trained division, brigade and regimental Gas Officers at Camp A. A. Humphreys, Virginia and later at Camp Kendrick, adjacent to Lakehurst, New Jersey. The program included a four-day general information class for junior officers and NCOs and a twelve-day course for Chief Gas Officers at division and higher echelons. A lecture on all aspects of gas warfare was followed by a gas mask drill five days a week during the training cycle. Men were then tested by masking in a chamber filled with chlorine gas and then unmasking in one with tear gas.[8]

## A New Branch for the U.S. Army

In June 1918, President Wilson ordered the army to establish a separate Chemical Warfare Service. All activities were placed under the command of Major General William L. Sibert (1860-1935), a Corps of Engineer Officer and former commander of the 1st Infantry Division. Siebert not only had technical knowledge but had also led the first U.S. combat unit to see action in France. The CWS was composed of ten divisions: Administration, Research, Gas Defense, Gas Offense (Edgewood Arsenal), Development, Industrial Relations, Production, Proving (testing), Medical, Training, Overseas Gas Service, AEF) and the 1st Gas Regiment (deployed to France). With the exception of the Overseas Division and the 1st Gas Regiment, the division chiefs were located in Washington, D.C., and their operations were scattered in locations throughout the United States.[9]

The CWS structure in the United States was based on personnel needs in combat and gas related equipment requirements. The Administration Division offices were located in Washington and facilitated routine matters, budgeting, and requisitions, and coordinated the other division’s activities. Its Industrial Relations Section was responsible for designating plants that were essential to the war effort and deferred chemists from military service. The University Relations Section recruited chemists at educational and research institutions. It also made certain that all drafted men with chemistry degrees be identified and assigned to positions where their knowledge could be utilized.[10]

A Research Division, as the name implied, handled all basic investigations, from the discovery of new chemicals to the development of protective masks and offensive equipment. The Gas Defense Division also handled research but primarily administered the testing and inspection of gas masks for men and animals. This unit was also responsible for manufacturing gas-proof dugout blankets and protective clothing, including gloves, anti-gas ointment, and “gas warning” alarm devises. The Development Division experimented with charcoal for gas mask filters from a variety of sources, including nutshells and fruit pits, coconut shells and even the Philippine Monaca Palm tree fruit nut, since it was found to be as efficient as coconuts.[11]

The Development Division also invented a process for manufacturing mustard gas with a shell casing and adaptor for the corrosive chemical similar to the French 75mm shells which were lined with glass. Until one was developed U.S. artillery used the French 75-mm and U.S. three inch shell filled by the French. The Proving Division tested prototype shells before production and prior to shipment. The Medical Division coordinated work in the therapy, pharmacology, physiology, and pathology of the war gases on a human body. Its emphasis was on prevention and treatment of casualties from mustard gas.

The CWS Training Division had the most direct and important impact on AEF’s unit’s performance regarding prevention. Its responsibilities included the organization and training of gas troops, gas officers, “casual” detachments for overseas duty, and a Chemical Warfare Training Camp. The Division’s importance was evident; Chemical Warfare’s Assistant Director, Brigadier General Henry Clay Newcomer (1861-1952) had operational command and it was the only division in the CWS, other than Administration, that was headed by a general officer.[12]

Edgewood Arsenal in Maryland produced the most significant war chemicals, including chloropicrin, phosgene, mustard, chlorine, and sulfur monochloride. Yet its capacity was stretched to the limit. Other manufacturing sites were therefore contracted and run by military officers at five other locations. Most war chemicals existed prior to the war. However, a new substance, Lewisite, an arsenic compound, was the only war gas invented in the U.S. Captain W. Lee Lewis (1878-1943) at Northwestern University created it. As a vesicant similar to mustard gas, Lewisite’s arsenic base easily penetrates the skin and is sufficient to kill in several hours. General Amos Fries (1873-1963), Overseas Director CWS, called it the “dew of death.” This new chemical was never used in Europe.[13]

## American Expeditionary Forces (AEF)

General John J. Pershing (1860-1948) attempted to mirror the AEF’s CWS to the new organization in the United States. He ordered the establishment of an overseas laboratory to investigate chemicals found on the battlefield. At the request of the Mellon Institute, the Fisher Scientific Company provided a director and assistant. Prior to the war the Fisher Company had depended heavily on German chemicals and laboratory equipment to conduct its own research on chemicals for U.S. industries and agriculture. Luckily, the last major shipment reached the U.S. prior to the declaration of war. The company was able to assemble the necessary laboratory equipment and existing chemicals to ship overseas.[14]

Another chemical research laboratory was located at Puteaux near Paris in a former medical research laboratory. It was divided into five divisions: organic, physicochemical, mechanical, control, and miscellaneous. At its peak between sixty and seventy civilian chemists worked there. Several were commissioned as officers; some civilian chemists, such as Gilbert N. Lewis (1875-1946) and Joel H. Hildebrand (1881-1983), became noted in their fields. One project was a search for a way to conceal the odor of a chemical used in offensives. Chemists added butyl sulfide to mustard gas, giving it a strong skunk odor. As the French countryside was heavily populated by skunks, it was hoped that the smell would mislead the Germans and hide the presence of gas. However, butyl sulfide was never used. The chemists also stayed abreast of the latest changes in chemical warfare by reviewing British and American gas officer reports, chemical battlefield specimens and captured German documents.

Now armed with a way to research new gases used by the Germans, GHQ AEF issued General Order 79 to establish divisions, corps, and gas officers. These officers were directly responsible to the commanding officers. Regimental and battalion gas officers and NCOs reported weather, terrain, new enemy tactics and material to each company commander. The order also established a Gas Defense School in France. To keep abreast of new gases and additions to defensive measures, the school commander was to coordinate the curriculum with the U.S. 1st Gas Regiment and the Puteaux laboratory.[15]

## Chemicals on the Offense

The German use of chemical shells during the Spring Offensive caused the AEF to expand the gas officer duties at all levels. After 2 July 1918 unit commanders consulted gas officers and their technical knowledge was utilized in the planning of all operations that involved the extensive use of gas, whether by artillery or other means. There was a continual shortage of chemical warfare ammunition. In September 1917 the AEF requisitioned 50,000 [gas] cylinders and 50,000 "Livens" gas projectors, Stokes mortars (none existed in the U.S.) and chemical shells. None of these weapons ever arrived in France even though U.S. chemical plants produced 3,600 tons of various types of war gasses. These chemicals, however, were delivered in 55-gallon drums to manufacturing facilities in Britain and France. Almost all chemical delivery systems, artillery, mortars, Livens projectors, and cylinders had to be purchased from British and French sources.[16]

Specialized units trained for offensive chemical warfare. The U.S. 30th Engineers, 1st Gas Regiment trained with the British under the direct supervision of Brigadier General Charles A. Foulkes (1875-1969), commanding the Special (Gas) Brigade. The soldiers used British cylinders, Livens Projectors, and Stokes mortars. American officers and men were detailed to the British sector and assigned to the Brigade Companies to observe operations. After extensive training the Companies deployed to the U.S. sector where U.S. officers had little or no training on how to integrate chemical weapons in combat. However, during the final offensive campaigns of Chateau-Thierry and St. Mihiel, the regiment's companies were able to move with the advancing forces using Stokes mortars to fire smoke, thermite, and gas.[17]

Many of their missions occurred in open warfare. The 1st Gas Regiment's companies fired Stokes mortars to support advancing infantry; using thermite shells on machine gun emplacements, they covered advancing troops with smoke. Time permitting, Livens projectors were dug just forward of the trench line, usually the night before the attack. The regiment deployed individual companies and platoons at the request of infantry operations planners.

The other offensive delivery system for the AEF was artillery. U.S. artillery used two classes of gas bombardment. The first was "destructive fire," consisting of two minutes of rapid fire with rounds landing in close proximity to create a dense cloud and heavy casualties. The second class used was a "neutralizing fire," where shells were fired over a long period to lower physical resistance and morale. Interdiction fire was to render fixed positions untenable. An AEF barrage consisted of 25 percent gas or the fire of one gun per battery. This was also a ruse, making the enemy believe that the barrage was only composed of gas shells and causing him to mask while the attacking infantry did not require protection. This fire was to disrupt the enemy, block reinforcements, and prevent counterattacks. Counter battery fire became extremely effective because of the use of mustard gas, which was a persistent agent (most of the chemicals fired were in the non-persistent category). The use of chemical supporting fire in an attack was left to the discretion of an infantry division staff.[18]

## Gas Casualties

Lieutenant Colonel Harry Gilchrist, M.D. (1879-1943), AEF Gas Service Medical Director, published a manual for treating chemical wounds. The U.S. Medical Service even fielded a mobile decontamination station to reduce mustard casualties, which, unfortunately, came too late to deploy. Thus as casualties mounted, one out of four field hospitals per combat division was dedicated solely to treating gas victims. The AEF suffered 34,249 immediate deaths in combat; of those 200 were due to chemicals. 224,089 AEF soldiers were wounded; of these 70,552 suffered from gas inflicted wounds and 1,221 died in hospital. When examining the figures, 27.3 percent of all American casualties, dead and wounded, were caused by gas. A significant 31.4 percent of all wounded were victims of chemical warfare.[19]

## Conclusion

The chemical industry, private institutions, and universities all insured rapid chemical warfare production in the U.S. that not only equaled that of France and Great Britain, but was also four times the amount produced by Germany. It had developed a Chemical Warfare Service and industrial and research base to equal its allies and Germany.[20] By 11 November 1918 the U.S. was able to wage offensive chemical warfare and was on its way to producing its own offensive and defensive measures, equipment, and munitions for employment in combat.

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## Notes

1. ↑ The terms “chemical warfare” and “gas warfare” were used interchangeably.
2. ↑ Brophy, Leo P./Fisher, George J. B.: United States Army in World War II. The Chemical Warfare Service. Organizing for War, Washington, D.C. 1959, pp. 2-5.
3. ↑ Brophy, Leo P./Miles, Wyndhan D./Cochrane, Rexmond: The Chemical Warfare Service. From Laboratory to Field, Washington, D.C. 1959, pp. 8-9; Bancroft, Wilder D. et.al.: Medical Aspects of Gas Warfare. The Medical Department of the United States Army in the World War, vol. 14, Washington, D.C. 1926, p. 34; Fries, Amos A./West, Clarence J.: Chemical Warfare, New York 1921, p. 33.
4. ↑ Brown, Frederick J.: Chemical Warfare. A Study in Restraints, Princeton 1968, p. 22.
5. ↑ Bancroft, Medical Aspects of Gas Warfare 1926, p. 34; Fries and West, Chemical Warfare 1921, p. 33.
6. ↑ Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, pp. 19-20.
7. ↑ Auld, Samuel James Manson: A General Record of the American Chemical Warfare Service and the Relations Therewith the British Mission, 5 section, 2:4, not catalogued, date unknown, Edgewood Arsenal, Maryland, Chemical Warfare Vault.
8. ↑ Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, pp. 1, 3-5; Chief, Chemical Warfare Service, A.E.F., to all gas officers, 28 September 1918, Subj: Gas Defense Training, 35th Division Gas Officer File, Record Group 120, National Archives, Washington, D.C.
9. ↑ Prentice, Augustin Mitchell: Chemicals in War. A Treatise on Chemical Warfare, New York 1937, pp. 81-82; Fries and West, Chemical Warfare 1921, pp. 36-69.
10. ↑ Fries and West, Chemical Warfare 1921, pp. 36-37.
11. ↑ Ibid, pp. 36-37; Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, pp. 13, 18-21.
12. ↑ Fries and West, Chemical Warfare 1921, pp. 60-70; Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, pp. 12- 13.
13. ↑ Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, p. 17; Fries and West, Chemical Warfare 1921, p. 23.

14. ↑ Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, pp. 9-12.
15. ↑ Ibid, pp. 10-12; General Orders A.E.F., G.O. no. 79, 27 May 1918, pp. 327-29. G. 0., A.E.F., G.O. no.79, 27 May 1918, pp. 327-29.
16. ↑ Prentiss, Chemicals in War 1937, p. 462.
17. ↑ Addison, James Thayer: The Story of the First Gas Regiment, New York 1919, p. 115.
18. ↑ U.S. Army, A.E.F., 1917-1918, 1st Army, Provisional Instructions for Artillery Officers on the Use of Gas Shell Chaumont 1918, n.p.; U.S. Army, A.E.F. Gas Manual, Pt. 2, Use of Gas by the Artillery, Chaumont 1918, n.p.; U.S. Army, Chemical Warfare Service, History of the Chemical Warfare Service, American Expeditionary Forces, 1918, 43 Defense Technical Information Center.
19. ↑ In researching gas/chemical casualties, I found minor discrepancies and a variety of reporting methodology. The studies I examined included: Love, Albert G.: Statistics, Pt. 2, Medical and Casualty Statistics. The Medical Department of the United States Army in the World War, vol. 15, Washington, D.C. 1925; Love, Albert G.: War Casualties, Army Medical Bulletin no. 24, Carlisle Barracks, PA 1931; Gilchrist, Harry L.: A Comparative Study Of World War Casualties From Gas and Other Weapons, Edgewood Arsenal, MD 1928. The latter provided the clearest format figures substantiated by the latter studies. Figures do not include the U.S. Marine Brigade deployed with the U.S. Army.
20. ↑ Brophy, Miles and Cochrane, The Chemical Warfare Service 1959, p. 19; U.S. Department of the Army, Historical Division, United States Army in the World War, 1917-1918, vol. 16, General Orders, G.H.Q. A.E.F. G.O. no. 79 27 May 1918, pp. 327-29.

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Technology is equally vital to science, as scientists rely on new and better technology to conduct increasingly sophisticated experiments; for example, nanotechnology allows researchers to observe and manipulate gases, liquids, and solids at the nanoscale, or one-billionth of a meter. The symbiotic relationship between science and technology is ubiquitous. The space program, for instance, must combine astronomy, physics, and mathematics with engineering, computing, and information science in order to launch its rockets. Meteorologists combine information gathered by satellites with their knowledge of the earth sciences in order to predict the weather. Top 5 educational institutions USA with Science and technology, programs for international students. Reviews are available. Free application and admission support. No extra charges. Discounts are available, please check discounts section.Â  Education information. Please check for 5 highly ranked educational institutions in USA where you can study Science and technology. Below you can find detailed information with description, programs, prices, photos and videos. Our expert consultants are always happy to help you choose the right program and give professional advice and recomendations. United States of America. Science and technology by country in North America: Bahamas. Barbados. Belize. Canada. Costa Rica. Cuba.Â  LARA core winder in Philedelphia-USA.jpg 1,200 Ã— 900; 387 KB. Laser glass slabs.jpg 442 Ã— 308; 57 KB. Lasertv vs plasma.png 496 Ã— 166; 91 KB. Lauren-logo.jpg 858 Ã— 262; 52 KB. LCL.png 244 Ã— 260; 69 KB. Lewis Howes.jpg 667 Ã— 1,000; 304 KB. LightHair.jpg 300 Ã— 240; 12 KB.