

# Chapter 2

## HISTORY OF CHEMICAL WARFARE

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## INTRODUCTION

A chemical agent is a substance “intended for use in military operations to kill, seriously injure, or incapacitate man because of its physiological effects.”<sup>1(p1-1)</sup> Chemical warfare agents cause injuries directly by irritation, burning, or asphyxiation, and indirectly by contaminating ground so that it cannot be safely occupied, creating smoke screens to obscure operations or reduce the accuracy of an enemy’s firepower, and damaging an enemy’s equipment by incendiary action. In short, chemical warfare is the use of any synthetic compound or material designed and used for the purpose of harming others. In the modern era, chemical agents have been divided into five categories: nerve agents, vesicants, choking agents, blood agents, and incapacitants. Excluded from consideration in this chapter are riot control agents, chemical herbicides, and smoke and flame materials.

Chemical warfare evolved from studies of plant poisons by ancient Egyptian and Indian civilizations to the studies of Aristotle, Mithridates, Galen, da Vinci, and Nobel scientists at the turn of the 20th century.<sup>2</sup> The concept that chemicals can be used as deadly poisons on a small scale has been understood since the start of written civilization, and evidence of their use has pervaded myth and history for thousands of

years. Some scholars suggest that the English colonists at Jamestown were poisoned with arsenic trioxide by Spanish operatives intent on maintaining a monopoly in the New World. Throughout history, individuals used plant poisons and chemicals to remove romantic and political rivals, despotic rulers, prisoners, and even unwanted spouses. Despite these small-scale uses of chemical poisons before the 20th century, military use of chemicals was rare. In the early 20th century, World War I changed the face of warfare with the use of chemicals on a massive scale.

This chapter, the first in a series of three chapters on the history of chemical warfare, focuses on the historical development of chemical warfare, its large-scale use during World War I, post-World War I incidents of chemical warfare, legislative efforts to ban chemical agent use, chemical warfare plans during World War II, and chemical warfare and terrorism today. The discussion will emphasize the historical experiences of the United States on the battlefields of Europe, Asia, and North Africa. It will be followed by Chapter 3, History of the Medical Management of Chemical Casualties, and Chapter 4, History of the Chemical Threat, Chemical Terrorism, and the Implications for Military Medicine.

## CHEMICAL CONCOCTIONS USED IN BATTLE

### Toxic Smokes

The first recorded history from civilizations in Egypt, Babylon, India, and China contain references to deadly poisons. The first pharaoh, Menes, cultivated, studied, and accumulated poisons from plants, animals, and minerals in 3000 BCE. Egyptians also investigated the lethal effects of hydrocyanic acid.<sup>2</sup> Beginning in 2000 BCE, the great dynasties in India used smoke screens, toxic sleep-inducing fumes, and incendiary devices on a large scale during battle.<sup>2,3</sup> Chinese writings from 1000 BCE contain recipes for the production of poisonous, noxious, and irritant vapors for use in war, including arsenic-containing “soul-hunting fog.” The Chinese also developed stink bombs of poisonous smoke and shrapnel, along with a chemical mortar that fired cast-iron “stink” shells.<sup>4</sup>

The powerful city-states of ancient Greece also experimented with chemical concoctions. During the First Sacred War in 590 BCE, Athens and Sicyon plotted to lay siege to the fortified city of Kirrha in retaliation for the harassment of pilgrims to the Oracle of Apollo at Delphi. Solon, the sage of Athens, had the River

Pleistos, the main water supply to Kirrha, poisoned with hellebore roots, causing diarrhea that led to the defeat of the besieged city (as described by Pausanias in 150 BCE). Thucydides described the first use of chemical warfare in Western civilization, by Sparta against Athens, in his *History of the Peloponnesian War* (431–404 BCE). During the siege of Plataea in 428 BCE, wood was saturated with pitch and sulfur to generate arsenic smoke, and then burned under the walls of the city to produce poisonous choking fumes (as well as fear and panic). A rainstorm minimized the effect, but the strategy was successfully employed again by Sparta and its allies during the siege of Delium, an Athenian fortification, in 424 BCE. Dating from the 4th century BCE, Mohist sect manuscripts in China describe chemical tactics employed against entrenched, well-defended armies in caves and tunnels, using bellows to pump smoke from burning balls of mustard and other toxic plants.<sup>3,4</sup>

Chemical warfare was also practiced during the time of the Roman empire. About 200 BCE, the Carthaginians left mandrake root in wine to sedate the enemy.<sup>4</sup> Inhabitants of Ambracia in Epirus used toxic smoke to deter the Romans from breaching their walls.<sup>5</sup> Between 82

and 72 BCE the Romans used a toxic smoke that caused blindness and choking pulmonary symptoms when inhaled, similar to phosgene.<sup>6</sup> This tactic allowed the Romans to defeat the Spanish Charakitanes in only 2 days. During the 15th century CE, arsenic smokes were used by Christians against the invading Turks at the siege of Delium. Austrian historian von Senfftenberg wrote about the arsenic cloud: "It was a sad business. Christians must never use so murderous a weapon against other Christians. Still, it is quite in place against Turks and other miscreants."<sup>7(p7)</sup>

### Greek Fire and Flaming Concoctions

The Greeks found ways to use their static burning concoctions of pitch, sulfur, tow, and resinous wood chips with incendiary arrows, flaming pots shot from catapults, and fire cannons mounted on boats. The most famous of all the ancient methods of chemical warfare, Greek fire, helped ensure the success of the Byzantine Empire. Although the exact formula for Greek fire has been lost to history, the ingredients included resin, pitch, sulfur, naphtha or petroleum, quicklime, and saltpeter. Discharged from tubes in the bows of ships, the mixture ignited on contact with water and burned on the surface of the sea. Greek fire was invented by Kallinikos (sometimes called Callinus), who arrived in Constantinople in 668 CE after fleeing Muslim-occupied Syria. The Byzantines had used naphtha siphons and squirt guns in 513, but Kallinikos's idea to pump pressurized naphtha through bronze tubes to ignite enemy ships broke the Muslim siege of Constantinople in 677 CE, enabling the Byzantine navy to rule the seas and the Byzantine empire to flourish for many years.<sup>3</sup>

### Poison Projectiles in Siege Warfare

The Renaissance spawned an interest in novel war machines and chemical weaponry. Leonardo da Vinci proposed a machine in the 15th century to fire shells filled with a powder mixture of sulfur, arsenic, and verdigris (copper acetate).<sup>8</sup> Aimed at ships' galleys, the projectiles poisoned the lungs of anyone in the vicinity of the dispersed powder. In the 1600s incendiary shells

filled with sulfur, tallow, rosin, turpentine, saltpeter, and antimony were used to start fires in sieges. Similar toxic smoke projectiles were designed and used during the Thirty Years War (1618–1648). In 1672, during his siege of the city of Groningen, Christoph Bernhard van Galen, the Bishop of Münster, employed several different explosive and incendiary devices containing belladonna alkaloids intended to produce toxic fumes. In response to the use of poison projectiles, the French and Germans signed the Strasbourg Agreement just 3 years later on August 27, 1675. This was the first documented international agreement to ban the use of "perfidious and odious" toxic devices.<sup>4</sup> In addition to their use as gaseous poisons, militaries also used chemicals to gain an advantage under the cover of thick haze. In 1701 Charles XII of Sweden used chemical smoke screens to obscure his crossing of the Dvina River under a gas cloud.<sup>9</sup>

In 1854 Lyon Playfair, a British chemist, proposed a cacodyl cyanide artillery shell for use against enemy ships as a way to resolve the stalemate during the siege of Sevastopol. Although British Prime Minister Lord Palmerston considered the idea, the British Ordnance Department rejected it, calling it as "bad a mode of warfare as poisoning the wells of the enemy."<sup>10(p22)</sup> Playfair's response was used to justify chemical warfare into the next century:

There was no sense in this objection. It is considered a legitimate mode of warfare to fill shells with molten metal which scatters among the enemy, and produced the most frightful modes of death. Why a poisonous vapor which would kill men without suffering is to be considered illegitimate warfare is incomprehensible. War is destruction, and the more destructive it can be made with the least suffering the sooner will be ended that barbarous method of protecting national rights. No doubt in time chemistry will be used to lessen the suffering of combatants, and even of criminals condemned to death.<sup>10(pp22-23)</sup>

A few years later, citizens of the fragmenting United States began considering the first American proposals for chemical warfare.

## CHEMICAL WARFARE PROPOSALS IN THE US CIVIL WAR

New York schoolteacher John Doughty is credited with developing the first American proposal for chemical warfare. Pitching his idea to the War Department in 1862, Doughty advocated the offensive use of chlorine gas by launching an artillery shell filled with 2 to 3 quarts of liquid chlorine. After the shell exploded, the chlorine gas would rout "an entrenched enemy" or

ward "off the attacks of iron-clad vessels and steam rams."<sup>9(p6)</sup> Doughty added:

If the shell should explode over the heads of the enemy, the gas would, by its great specific gravity, rapidly fall to the ground: the men could not dodge it, and their first intimation of its presence would be by its inhalation, which would most effectually disqual-

ify every man for service that was within the circle of its influence; rendering the disarming and capturing of them as certain as though both their legs were broken.<sup>11(p27)</sup>

Although Secretary of War Edwin M Stanton apparently never answered it, Doughty's letter was later published in the *Journal of the American Military Institute*.<sup>9</sup> The idea was one of many suggestions and inventions flooding the War and Navy Offices during the time, including a proposal by Joseph Lott of Hartford, Connecticut, for using hand-pumped fire engines to spray chloroform on Confederate garrisons to anesthetize troops prior to their capture.<sup>12</sup> Over 50 years after Doughty's original proposal, the German army developed chlorine gas cylinders and eventually chlorine bombs to combat trench warfare in World War I.

During the 1864 siege of Petersburg, General Ulysses Grant's army was stalled outside the city. Forrest Shepherd, a professor of agricultural chemistry at Western Reserve University, proposed mixing hydrochloric and sulfuric acids to create a toxic cloud to defeat the entrenched Confederate defenders.<sup>11</sup> Because chemical warfare was viewed as inhumane at the time, Grant never acted upon the plan. Other such ideas were recorded during the war. Union Army Captain EC Boyton proposed the use of a cacodyl glass grenade for ship-to-ship fighting.<sup>11</sup> Lieutenant Colonel William W Blackford, a Confederate engineer, designed a sulfur cartridge for use as a counter tunneling device.<sup>13</sup> The Confederates also considered using Chinese stink bombs against the Union troops. With the possible exemption of Blackford's cartridge, none of the proposals were applied on the battlefield.

## WORLD WAR I

### Chemical Warfare Use by France, Great Britain, and Germany

Most casualties in warfare from the Middle Ages until the First World War were the result of cold steel, wooden projectiles, and fast-moving metals propelled by explosives. World War I ushered in a new style of fighting involving stalemates of trench warfare (Figure 2-1), and synthetic chemists tested new chemical weapons in the arena of "no man's land." Trenches made

bullets less useful and reduced mobility, but poison gas could uproot a well-entrenched enemy.

All of Europe was caught in the crisis of 1914 after the murder of Archduke Francis Ferdinand at Sarajevo. Declarations of war among Austria-Hungary, Serbia, Germany, France, Russia, and Great Britain soon followed (Figure 2-2). The United States remained neutral for several years under President Woodrow Wilson's policy. Although few expected the 19th century chemical proposals to become instrumental in tactical operations on the battlefield, the highly skilled research scientists and chemists of the principal combatants quickly adapted chemicals as primary weapons. Early in the war, French intelligence and captured German prisoners warned the Triple Entente (the United Kingdom, France, and Russia) of the numerous German factories being built along the Rhein that were capable of synthesizing vast quantities of toxic chemicals for use on the battlefield. Despite international efforts to restrict chemical weapons in the late 19th and early 20th centuries (see Chapter 4, History of the Chemical Threat, Chemical Terrorism, and Its Implications for Military Medicine), as both sides became rooted in their labyrinth of trenches in the early stages of World War I, the armies turned to chemical warfare.



**Fig. 2-1.** Trench warfare. American Expeditionary Forces Second Division soldiers alerted to the sounds of gas alarms. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

### Early Allied Chemical Warfare Plans

Despite the long-held belief that Germany was the first to use chemical agents during World War I, the French were actually the first; in August 1914, they fired toxic gas from rifles in the form of ethyl bromoacetate tear gas grenades. The French had tested



Fig. 2-2. Map of western Europe in World War I. Symbols depict major cities, lines indicating the furthest extent of German occupation, and battles where the American Expeditionary Forces engaged German lines in chemical warfare. Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.

ethyl bromoacetate grenades before the war, and they continued to use tear agents against the Germans throughout the conflict. However, the ineffectiveness of these weapons caused poison agents to remain unnoticed until the Second Battle of Ypres in 1915.

The British also examined their chemical technology for battlefield use in the early stages of the war, investigating tear agents but later turning to more toxic chemicals. In January 1915 several chemists at the Imperial College gassed a representative of the War Office, successfully demonstrating the use of ethyl iodoacetate as a tear gas. A suggestion for using sulfur dioxide as a chemical weapon, after being rejected for the army by Field Marshal Lord Kitchener, was presented to Winston Churchill at the admiralty in March 1915. The proposal included a plan to use a

sulfur dioxide cloud against the Germans, a smoke screen to provide cover, and gas-proof helmets for British troops. Churchill rejected the plan but formed a committee the following month to discuss the use of smoke on land and sea.<sup>14</sup>

#### *German Chemical Warfare Plans*

Possibly aware of the Allied interest in chemical weapons, the Germans also pursued war applications for chemical technology. The strong German dye industry and the plethora of scientists in Berlin created an ideal situation for developing offensive chemical weapons. Professor Walther Nernst, recipient of the 1920 Nobel Prize in chemistry, suggested placing trinitrotoluene (TNT) in a 105-mm shrapnel shell with dianisidine

chlorosulphonate, an agent known to cause irritation to the mucous membranes.<sup>15</sup> Germans called these "Nernst Ni-Shrapnel" or "ni-shells," partly derived from the German word for sneezing powder, "niespulver." After the French deployed tear gas, Germany saw no reason to refrain from using its own chemical weapons.

### ***Western Front: The Battle at Neuve-Chapelle***

Germany first tested the Nernst weapon on the western front. On October 27, 1914, 3,000 of these shrapnel irritant shells fell on British and Indian troops near Neuve-Chapelle in Northern France. Although the British were unprepared for such an attack, the soldiers suffered no ill effects. The Germans remained convinced that chemicals had merit, however, and continued to experiment with new gas formulations.<sup>15</sup>

### ***Eastern Front: T-Shells at the Battle of Bolimov***

Three months after Neuve-Chapelle, the Germans tried xylyl bromide (a form of tear gas) on the Russian front in Poland. The Battle of Bolimov, launched on January 31, 1915, preliminary to the Second Battle of the Masurian Lakes, was the site of the German army's first extensive use of poison gas. Germany employed a new gas shell ("Tappen-shell," "T-shell," or "T-Stoff") that contained an explosive charge for producing a duel shrapnel and poison effect, designed by Professor Hans von Tappen of the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry in Berlin. For the new weapon, von Tappen made two improvements to Nernst's shells. First, he stabilized the chemical liquid within the shell casing to reduce tumbling when fired from a standard 15-cm howitzer, increasing the shell's accuracy and range. Second, he designed a shell casing to prevent accidental mixing of the extremely reactive chemical substances inside. Each shell contained 7 lb of xylyl bromide, a burster charger for splinter effect, and a lead lining to prevent contact between the burster charge and the chemical payload.<sup>15,16</sup>

However, the firing of 18,000 shells at Russian positions around Bolimov proved entirely unsuccessful. The Russians easily repulsed the overconfident German attack and the German gas failure halted any further assaults on Bolimov. The chemical failed for several reasons. The winter weather was too cold to cause the liquid to vaporize to the gaseous state, and the agent was either blown back towards the German lines or fell harmlessly to the ground. Also, xylyl bromide was a weakly irritating tear gas, and the liquid could not be dispersed in sufficient concentration to cause damage. Although aware that the Germans had attempted an attack with poison gas, the Russians

did not widely report it to their Western allies because of its failure. The Germans again attempted to use T-shells on the western front at Nieuport in March 1915, with similar results.<sup>14,17,18</sup> Although unsuccessful, these experiments provided Germany with the experience to improve future attempts. Poison gas next appeared with much greater success on the western front in April 1915, during the Second Battle of Ypres .

### ***Development of Chlorine***

Fritz Haber, professor at the Kaiser Wilhelm Physical Institute of Berlin (and later the 1918 Nobel Laureate in chemistry), directed German field operations involving chemical warfare (Exhibit 2-1). Haber is credited with the concept of creating a toxic cloud from chemical cylinders in late 1914. Learning the lessons from von Tappen's T-shells, Haber suggested the use of large commercial gas cylinders as a delivery system instead of artillery shells, which were in short supply. He also postulated that gas from storage cylinders would cover a far broader area than gas dispersed from artillery shells. In addition, neither the T-shell nor the chlorine gas cylinders technically violated the Hague ban on projectiles. Haber selected chlorine because it was readily available from the German dye industry and satisfied requirements for military application: it was lethal, immediately effective, nonpersistent, and volatile. Chlorine could form a toxic gas cloud dense enough to resist dilution in a moderate wind but with no prolonged influence over the terrain.<sup>15</sup>

### ***The Second Battle of Ypres***

During October and November 1914, the French, British, and Belgian forces had stopped the advance of Germany's Schlieffen Plan, at great costs to both sides. The First Battle of Ypres had resulted in a stalemate, with each side entrenched. Germany selected the front of the Fourth Army facing the French at Ypres as the location for a gas attack (see Figure 2-2). On March 10, 1915, Pioneer Regiment 35, under Haber's guidance, placed 1,600 large and 4,130 small cylinders (containing a total of 168 tons of chlorine) opposite the Allied troops defending Ypres.<sup>15</sup> The chosen site was a sector between Bixschoote and Langemarck in Belgium (Figure 2-3), a tactical weak point where French and British forces joined.<sup>9</sup> The English-speaking troops consisted of Canadians and the British 28th Division. The French troops were the 87th Territorial and 45th Algerian Divisions.<sup>9</sup> Pioneer Regiment 35 waited for winds to shift to the west toward Allied trenches before the actual gas attack was delivered late in the afternoon on April 22,<sup>14,15,17,19</sup>

## EXHIBIT 2-1

## WAR OF THE CHEMISTS

During World War I, chemists on both sides investigated over 3,000 chemical substances for potential use as weapons. The war between the nations was just as much a war between the chemists. Germany had two future Nobel Laureates in chemistry on their side, and France had one as well. The adoption of poison gas by the Germans in World War I is attributed to Professor Walther Hermann Nernst, a well-known physical chemist in Berlin. In recognition for his services to the German Empire, he was made a count late in the war. However, World War I was the setting for a strategic match between rival chemists, with Germany's Fritz Haber pitted against his French counterpart, Victor Grignard.

Fritz Haber played a major role in the development of chemical warfare in World War I. He developed early gas masks with absorbent filters and masterminded the first chlorine attacks at Ypres, Belgium. In his studies of the effects of poison gas, Haber discovered a simple mathematical relationship between the concentration (C) of the gas and the amount of time (t) it was breathed in, expressed as  $C \times t = k$ , where k is a constant. In other words, exposure to a low level of gas for a long time can cause the same result (eg death) as exposure to a high concentration for a short time. This relationship is known as "Haber's rule."

Haber's rival was Francois Auguste Victor Grignard, a French chemist and professor at the University of Nancy. During World War I, he was transferred to the new field of chemical warfare and worked on the manufacture of phosgene and the detection of mustard gas. His Nobel Prize in chemistry was awarded for devising a new method for creating carbon-carbon bonds in organic synthesis termed "the Grignard reaction," which allowed the means of synthesizing larger organic compounds from smaller starting materials.

Haber's wife opposed his work on poison gas and committed suicide with his service weapon after he personally oversaw the first use of chlorine in Ypres, Belgium. Haber defended gas warfare against accusations that it was inhumane, saying that death was death, by whatever means it was inflicted. In the 1920s he developed the cyanide gas formulation Zyklon B, which was used as an insecticide, especially as a fumigant in grain stores. The Nazis later used Zyklon B (hydrogen cyanide) gas chambers disguised as shower stalls beginning with the first and longest running Schutzstaffel camp at Dachau. In 1934, the Nazis forced Haber, a German Jew, to emigrate. Haber was a patriotic German who was proud of his service in World War I, for which he was decorated. He struggled to cope with the new reality that his enormous contributions to German industry were disregarded during his vilification by the Nazi regime. He died in exile in Basel after a grave illness.

Data sources: (1) Haber LF. *The Poisonous Cloud: Chemical Warfare in the First World War*. Oxford, England: Clarendon Press; 1986: 15-40. (2) Heller CE. No. 10 chemical warfare in World War I: the American experience, 1917-1918. In: *The Leavenworth Papers*. Fort Leavenworth, Kan: Combat Studies Institute, US Army Command and General Staff College; 1984: 6-7. (3) Szöllösi-Janze M. Pesticides and war: the case of Fritz Haber. *Eur Rev*. 2001;9:97-108. (4) Harris R, Paxman J. *A Higher Form of Killing: the Secret History of Chemical and Biological Warfare*. New York, NY: Random House; 2002.

when the weather and wind patterns were ideal for a toxic cloud (Figure 2-4).

The Allies claimed that 5,000 troops fell victim to the chlorine cloud (although this number was probably inflated for propaganda purposes).<sup>9,20</sup> The gas attack was successful, but the Germans grossly underestimated the chlorine's effects and, lacking sufficient supplies and reserves for an assault, failed to capitalize on the retreating Allied positions.<sup>14,15,17,19</sup> Any further possible German advance was stopped by Canadian troops at Kitchener's Wood while the British and French hastily organized a defensive front during the next 48 hours.<sup>9</sup>

Two days later, Germans conducted a second chlorine gas attack against the Canadian First Division northeast of Ypres, near Saint Julien, and four more cylinder gas attacks during May in the Ypres sector.

The German gas-aided capture of Hill 60 on May 5 was a significant blow to the Allies.

Although the Allies expressed great indignation about this inhumane and unfair weapon (despite their own development of chemical weapons), the Germans believed their use of nonprojectile shells to form gas clouds was within the guidelines of the Hague ban. The comments of General von Deimling, commanding general of the German Fifteenth Corps at Ypres, written sometime after the war, reflected the reason for initiating chemical warfare:

I must confess that the commission for poisoning the enemy, just as one poisons rats, struck me as it must any straight-forward soldier: it was repulsive to me. If, however, these poison gases would lead to the fall of Ypres, we would perhaps win a victory which



Fig. 2-3. Map of Belgian-French border showing the location of the French, Belgian, British, and German armies at the time of the Second Battle of Ypres.

Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.

might decide the entire war. In view of such a high goal, personal susceptibilities had to be silent.<sup>21(p5)</sup>

Despite the numbers of Allied casualties and prisoners, the battle was a mixed success. The Germans failed to take advantage of their success, but the Allies, made aware of the pending gas attack when British pilots

spotted the gas cylinders in the German trenches, were also unprepared.<sup>21</sup> One British soldier remarked:

Nobody appears to have realized the great danger that was threatening, it being considered that the enemy's attempt would certainly fail and that whatever gas reached our line could be easily fanned

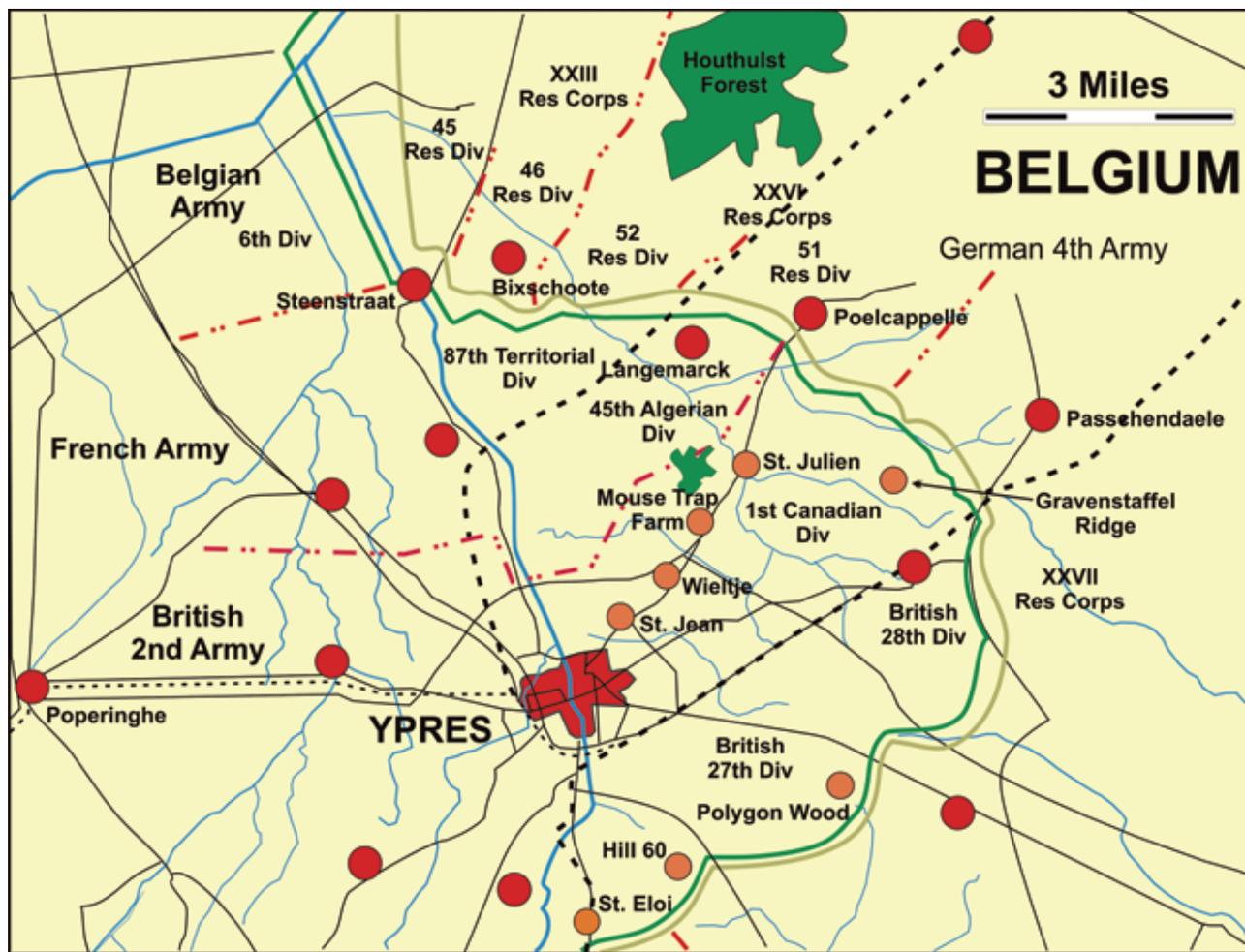


Fig. 2-4. Detailed map of Ypres, depicting the German, British, Canadian, and French fronts along the outskirts of town. This was the location of each major division prior to the release of chlorine shells on April 22, 1915. Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.

away. No one felt in the slightest degree uneasy, and the terrible effect of the gas came to us as a great surprise.<sup>22(p3)</sup>

Another observer, however, realized a profound change had occurred: "The most stupendous change in warfare since gunpowder was invented had come, and come to stay. Let us not forget that."<sup>23(p3)</sup>

Although chlorine had its disadvantages and the German attack against Ypres halted short of its objective, chemical warfare became a mainstay of German assaults and Allied counterattacks on the Ypres salient throughout the rest of the war (Figure 2-5). The Ypres sector became an experimental stage for the Germans to develop and test new gases on other battlefronts. A third battle occurred at Ypres in 1917 (at which the young Adolf Hitler was seriously wounded during an

Allied chlorine gas attack).

After the success at Ypres, Haber turned German attention back to the eastern front to atone for the failure of xylyl bromide T-shells. In May 1915 German troops again attacked Russians at Bolimov, releasing 263 tons of chlorine gas from 12,000 cylinders along a 7.5-mile line, killing 6,000 Russian soldiers. Two more gas cloud attacks on the same positions caused 25,000 more Russian casualties.<sup>15</sup> The Russians had initially devoted few resources to the development of chemical protective equipment. Consequently, they were more vulnerable to gas attacks than the British and French and suffered the greatest number of chemical casualties in World War I.

All of the first chemical attacks of World War I were in the form of chemical vapor clouds projected from cylinders, totaling nearly 200 by the end of the



**Fig. 2-5.** A French cylinder attack on German trenches in Flanders. The critical importance of the wind is apparent. Condensation of water vapor caused the cloud-like appearance of the gas.

Photograph: Courtesy of Chemical and Biological Defense Command Historical Research and Response Team, Aberdeen Proving Ground, Md.

war. Although the largest chlorine attack occurred in October 1915 at Reims, when the Germans released 550 tons of chlorine from 25,000 cylinders, chemicals delivered by artillery shells soon became the norm.<sup>9,15</sup> The Germans learned that a vapor cloud was dependent on wind direction and strength, neither of which could be predicted with any amount of accuracy. These initial chemical attacks also proved that an infantry attack synchronized with a discharged vapor cloud was extremely dangerous.

### *Allied Chemical Warfare Retaliation*

Only weeks after recognizing the potential of chemical weapons at Ypres, the British and French began planning a chemical retaliation, which became a three-pronged strategy to develop their own (1) protective devices for troops (Figure 2-6); (2) offensive toxic gas weapons; and (3) systems to deliver the toxic gases to enemy lines. The Allies developed their first protective mask the day after the first German chlorine attack, and in September 1915 they launched their own chlorine attack against the Germans at Loos, Belgium. These moves initiated a deadly competition to develop better protective masks, more potent chemicals, and long-range delivery systems to disperse the agents more widely. The Germans quickly replaced chlorine with phosgene, which was more effective. In May 1916 the Germans started using diphosgene, and 2 months later the French tried hydrogen cyanide (HCN), then



**Fig. 2-6.** Prevention of animal casualties during gas warfare was a concern. Photograph depicts gas masks on mule and soldier. Dun sur Meuse, Meuse, France. November 21, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

cyanogen chloride. In July 1917 the Germans introduced mustard agent to provide a persistent vesicant that attacked the body in places unprotected by gas masks. Both sides also mixed agents and experimented with camouflage materials to prevent quick agent identification.<sup>4</sup>

### *The Battle of Loos*

In the aftermath of Ypres, it became apparent that lacking an offensive gas capability would impair troop morale, and the British cabinet approved the use of chemical agents. It took 5 months to plan the large-scale gas attack at Loos, which involved chlorine-filled cylinders clustered in batteries along the front rather than spaced far apart in one continuous line. The British had a major numerical advantage against the Germans, reaching 7-to-1 in some places along the front. British commander General Douglas Haig began the offensive with a 4-day artillery bombardment by six divisions, planning to follow the bombardment with the release of 5,500 cylinders containing 150 tons of chlorine gas from the British front line.<sup>15(p11),20(p14-17)</sup>

The gas attack occurred on September 24 with only minimal success. Unfavorable and shifting winds reduced the effectiveness of the chlorine gas cloud, the number of chlorine cylinders was insufficient to cover the front line, and inadequate reserve divisions were available to exploit a breakthrough (a lesson learned by the Germans at Ypres).<sup>20</sup> A British shell shortage also

**EXHIBIT 2-2****PHOSGENE**

Chlorine's deficiencies were overcome with the introduction of phosgene, first used by Germany in December 1915. Phosgene, also known as carbonyl chloride ( $\text{COCl}_2$ ), is a highly toxic gas first synthesized by the chemist John Davy (1790–1868) in 1812 by exposing equal quantities of carbon monoxide and chlorine to sunlight. "Phosgene" comes from Greek, literally meaning "generated by light." Phosgene is colorless and 18 times more potent than chlorine. It is often only detected by its characteristic "moldy hay" odor. One disadvantage of phosgene as a chemical warfare agent was that it was lightweight and readily dissipated, but this problem was surmounted by addition of the heavier chlorine. The chlorine supplied the necessary vapor to help eject phosgene from containers. The British employed a chlorine-phosgene mixture they codenamed "white star," which was used heavily during the Battle of the Somme. Phosgene is a particularly insidious poison, as exposure often has no initial symptoms. Symptoms usually appear within 24 hours, but can take up to 72 hours to manifest. The gas combines with water in the tissues of the respiratory tract to form carbon dioxide and hydrochloric acid. The acid then dissolves the membranes in the lungs. Fluid fills the lungs, and death results from a combination of blood loss, shock, and respiratory failure. Phosgene was far more lethal than any other common-use gas weapon; 85% of western front soldiers were killed as the result of chemical attack by phosgene.

prevented sustained artillery barrages.<sup>15</sup> On the other hand, British Commander-in-Chief Sir John French acknowledged that although it failed to penetrate the German lines, the "gas attack met with marked success, and produced a demoralizing effect in some of its opposing units."<sup>15,16,23,24</sup>

Ultimately, both sides recognized the need to avoid vapors blowing backward and learned to launch

chemicals beyond a trench line using grenades, mortar bombs, and artillery shells. These realizations led to the introduction of the Livens projector and the Stokes mortar, critical advancements to chemical warfare. Both sides also achieved satisfactory protection against chlorine and began looking for newer, deadlier chemicals.

*Phosgene*

Phosgene was the next chemical to debut on the western front at the close of 1915 (Exhibit 2-2). The British, warned by intelligence in midsummer 1915 that Germany planned to use a new choking gas (Figure 2-7), had several months to make defensive preparations, including development of a new gas mask. The phosgene attack took place on December 11, 1915,<sup>9</sup> near the Wieltje ruins of the Ypres salient. The British were ready for the new gas, and the Germans lost a major opportunity to gain a decisive victory. Although gas masks could protect troops against its harmful effects, phosgene proved to be a very effective gas throughout the war, causing more deaths than any other gas in World War I.

The Germans may have used phosgene earlier, in late May and early June 1915, against Russian troops in the vicinity of Bzura and Rawka, and they used it extensively at Verdun in 1916.<sup>15</sup> The "white star" mixture of phosgene and chlorine (chlorine supplied the necessary vapor to carry phosgene) was commonly used on the Somme. When newer gas masks gave adequate protection against chlorine and phosgene, both sides realized that the vapor clouds were better suited as psychological



**Fig. 2-7.** "Gassed," a purportedly staged photograph under the direction of Major Everts Tracy, Engineer Corps, to illustrate the choking effects of phosgene. Location unknown. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

## EXHIBIT 2-3

### DIPHOSGENE

Trichloromethyl chloroformate ( $\text{ClCO}_2\text{CCl}_3$ ) was developed soon after the first use of phosgene in World War I. Like phosgene, it was also known as “green cross” because of the distinct markings on German shells containing the choking gas. The official German name was “perstoff.” The British used it under the name “superpolite” or “diphosgene,” while the French called it “surpalite.” It is a colorless, oily liquid with a distinct odor. It is similar to phosgene because it can break down under certain conditions to form two molecules of phosgene, but it does have an added tear-gas effect. Diphosgene, classified as moderately persistent, remains at the point of release for over 10 minutes.

weapons to create panic in the lines.

### *Diphosgene*

The Germans introduced diphosgene, another pulmonary agent, to their growing deadly arsenal in May 1916. This effective lung irritant and choking gas was dispersed via “green cross” shells, named for the shells’ distinct markings. As poisonous as phosgene and sometimes considered more toxic (Exhibit 2-3), diphosgene was developed because the vapors could destroy the gas mask filters in use at the time, and it had greater persistence in the environment than phosgene. Germany eventually deployed combinations of phosgene, diphosgene, and diphenylchlorarsine.

### *Mustard Gas*

Remaining consistently ahead in gas warfare



**Fig. 2-8.** American casualty from mustard being carried into gas hospital. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

development, Germany introduced mustard gas (sometimes referred to as “Yperite”) on July 12, 1917, against Canadian troops near Ypres. Mustard gas was distinguished by the serious blisters it caused both internally and externally several hours after exposure. Protection against mustard gas proved more difficult than against either chlorine or phosgene (Figure 2-8). The first large-scale mustard gas attack occurred just over a week after its first use, when the Germans attacked the British at Nieuport, resulting in over 14,000 casualties, 500 of whom died within 3 weeks. The next month the Germans fired 100,000 mustard shells, marked with a yellow cross, against the French Second Army, causing 20,000 casualties.<sup>25</sup>

In September 1917 Germany employed mustard-laden artillery shells against the Russians at Riga. The Allies did not use mustard until that November at Cambrai, after the British captured a large stock of German yellow cross shells. It took nearly a year for the British to reach large-scale mustard production on their own; they then used it extensively in breaking the Hindenburg line in September 1918.<sup>25</sup>

Major General Amos A Fries, head of the Gas Service of the American Expeditionary Forces (AEF) in France and later chief of the Army’s Chemical Warfare Service (CWS), recognized that mustard gas completely changed gas warfare. Although it was first used to produce casualties and fragment enemy troop concentrations, mustard caused 20,000 casualties in only 6 weeks after its introduction. Despite remaining potent in soil for weeks after release, making capture of infected trenches a dangerous undertaking, sulfur mustard lived up to its nickname as “king of the war gases” on the battlefield (Exhibit 2-4). The Germans caused 5,000 French casualties alone in a matter of 10 days during shelling of Verdun in September 1917. Germany continued to use mustard gas to great advantage throughout the winter of 1917–1918, producing casualties, creating confusion, and lowering morale among enemy ranks. In March 1918, during the last great German offensive (Operation Michael), the German army used mustard to neutralize the strongly defended city

**EXHIBIT 2-4****MUSTARD: "KING" OF THE WAR GASES**

Sulfur mustard was used extensively because it caused more casualties than any other chemical in World War I. The countermeasures against mustard were ineffective because gas masks did not afford protection against skin absorption.

Mustard takes its name from the unpurified form, which is yellow-brown with an odor resembling mustard, garlic, or horseradish. Other names for mustard are "yellow cross," "sulfur mustard," "hun stoffe (HS)," "Distilled Hun (HD)," "senfgas," "blister agent," "Yperite," "S-LOST," or "Kampfstoff LOST." LOST is derived from Lommel and Steinkopf, who developed the process for mass producing mustard during wartime use at the German company Bayer AG. Mustard is a thioether with the formula  $C_4H_8Cl_2S$ . The compound eliminates chloride ion by intramolecular nucleophilic substitution to form a cyclic sulfonium ion. This reactive intermediate is detrimental to cells of the body as a mutagen and carcinogen because it can bind to the guanine nitrogen in DNA strands, leading to cell death, cancer, and genetic alterations.

The term "mustard gas" is a misnomer; the agent is not a true gas. Dispersed as an aerosol, mustard is not water-soluble but contains high lipid solubility, contributing to its rapid absorption into the skin. Blister agent exposure over more than 50% body surface area was fatal during World War I; however, mustard was lethal in only 1% of cases. As a persistent agent, mustard can remain in the environment for days and continue to cause casualties. This property enabled its use as an area-denial weapon, forcing soldiers to abandon heavily contaminated positions. Contaminated clothing from one soldier could spread to others during battle.

Mustard gas is perhaps best known for the Bari disaster. A US stockpile on the SS *John Harvey* was bombed in Bari, Italy, in 1943 during World War II. This disaster exposed thousands of civilians and Allied troops to the chemical agent.

of Armentieres. During the battle, mustard was said to have "run in the gutters like water."<sup>9(p15)</sup>

Although the first gas attack on a US unit did not involve mustard exclusively, American soldiers feared mustard the most. Despite the many warnings, mustard agent injured over 27,000 Americans.<sup>25</sup>

**US Experience with Chemical Warfare**

The use of chemical warfare at Ypres in April, followed by the sinking of the *Lusitania* by a German U-boat off the Irish coast on May 7, 1915, rocked the United States. Americans began to take greater interest in the nature of warfare taking place in Europe and elsewhere. In May 1915 President Wilson proposed that Germany halt chemical warfare in exchange for the British ending their blockade of neutral ports. Both Germany and Great Britain refused to comply.<sup>26</sup>

**US Declaration of War**

Isolationism left the United States outside what was initially perceived as a European conflict. However, German mistakes resulted in America throwing its weight toward the Allies. Early in 1917 Germany resumed its policy of unrestricted submarine warfare. The Zimmerman telegram, a proposal to the Mexican government initiated by Germany to form an alliance

against the United States, was intercepted by the British, leading to public indignation and hastening the entry of the United States into the war. President Wilson asked Congress for a formal declaration of war on Germany on April 2, 1917. Congress declared war on Germany on April 6, and on Austria-Hungary in December 1917.

**US Preparation for Chemical Warfare**

The United States entered the war a full 2 years after the German army's first successful chlorine gas attack against the Allies. Although the US Army was aware of the increasing use of chemicals on both fronts, it made no effort to prepare for gas warfare until 2 months before the American declaration of war. As a result, the Army began the war with no doctrine or adequate training program for chemical warfare, depending on the Allies for gas-related equipment. However, once begun, preparations advanced quickly.

Only a day after Wilson's call to war, Congress established a subcommittee on noxious gases under the leadership of the director of the US Bureau of Mines. The subcommittee included Army and Navy ordnance and medical officers as well as two members of the chemical committee of the National Research Council. Its mission was to investigate noxious gases, the generation of chemical warfare agents, and the

discovery of antidotes for war purposes.<sup>19,27,28</sup> Within a short time, the subcommittee began organizing chemical agent research at universities and industries across the nation, while mobilizing a large portion of the chemists in the country. This initial phase laid the groundwork that later led to the establishment of the CWS, the precursor to the Chemical Corps.

The country's civilian scientists, engineers, and chemistry professors played a significant role in preparing the Army for chemical warfare. Eventually, the War Department also began to plan for chemical warfare, spreading responsibilities initially among the Medical Department, Ordnance Department, and Corps of Engineers. When General John J Pershing began organizing the AEF in France, however, he placed responsibility for all phases of gas warfare in a single military service and recommended that the War Department at home do likewise. On September 3, 1917, the AEF established a centralized Gas Service under the command of Lieutenant Colonel Amos A Fries.<sup>27,28</sup>

### *Creation of the Chemical Warfare Service*

In the spring of 1918 the US government began centralizing gas warfare functions in the War Department under a senior Corps of Engineers officer, Major General William L Sibert. President Wilson transferred the Bureau of Mines research facilities to the War Department, and on June 28, 1918, the CWS was formally established under Sibert as part of the National Army (the wartime Army, as distinguished from the Regular Army), with full responsibility for all facilities and

functions relating to toxic chemicals.

The CWS was organized into seven main divisions: (1) The research division, responsible for most of the weapons and agent research during the war, was located at American University near Washington, DC. (2) The gas defense division, responsible for the production of gas masks, had a large plant in Long Island City, New York. (3) The gas offense division was responsible for the production of chemical agents and weapons, its main facility located at Edgewood Arsenal, Maryland. (4) The development division was responsible for carbon production and pilot plant work on mustard agent production. (5) The proving ground division and (6) the training division were located together at Lakehurst, New Jersey. (7) The medical division was responsible for the pharmacological aspects of chemical defense.

The AEF's offensive chemical unit, the 1st Gas Regiment (formerly the 30th Engineers), was organized at American University under the command of Colonel EJ Atkisson in 1917, and sent to France in early 1918 (Exhibit 2-5).<sup>19,27</sup> The US Army finally had an organization that controlled offensive chemical production, defensive equipment production, training, testing, and basic research, along with a new chemical warfare unit unified under a single commander. This organization helped lead the AEF to victory, although much of its work, including the construction of facilities for producing toxic gas, filling plants, and producing gas masks, was only partially completed by the end of the war.

America entered the Great War in bleak circumstances. The failed French offensive in the spring gave

#### **EXHIBIT 2-5**

#### **EARLIEST REPORTED DESCRIPTION INVOLVING CHEMICAL WARFARE ON THE AMERICAN EXPEDITIONARY FORCES**

The Germans attacked on February 2, 1918, using a bombardment of 25 phosgene or diphosgene shells. The shells were recognized by their "swish and wobbly sound in passage," fired harmlessly by the German army near the 6th Field Artillery in Hazelle woods in the late afternoon. The first American offensive instruction to attack with gas was issued that same day by Major General Bullard. The 1st Division engaged in a long barrage of 6,750 high explosive shells, with the German artillery in retaliation, and fired 80 gas shells on seven German batteries, consisting of No. 4 (cyanogen chloride) and No. 5 (phosgene) gas shells. The French disapproved of this tactic because the firing was fast and long-lasting. This marked the first gas volley between German and US armies. Several days later, on February 6, 1918, the Germans fired one shell containing mustard gas along with numerous high explosive shells, marking the first time that mustard was used on American forces. The first gas casualties were tallied from that shell; three soldiers of the 6th Field Artillery, Battery A, were evacuated with acute conjunctivitis the following day, and a gunner with a burned buttock was evacuated 2 days later.

Data source: Spencer EW. *The History of Gas Attacks Upon the American Expeditionary Forces During the World War, Part I*. Edgewood Arsenal, Md: Chemical Warfare Service, US War Department; 1928: 32-33.

TABLE 2-1

**WORLD WAR I AMERICAN EXPEDITIONARY FORCES IN OFFENSIVE AND DEFENSIVE BATTLES INVOLVING CHEMICAL WARFARE**

<b>Date</b>	<b>Battle</b>	<b>Participants</b>
November 20–December 4, 1917	Cambrai (France)	11th, 12th, and 14th Engineers
March 21–April 6, 1918	Somme defensive (France)	3rd Division; 12th, 14th Engineers; 2nd, 3rd, 4th Pursuit Groups
April 9–27, 1918	Lys (Belgium)	11th, 16th Engineers; 3rd Pursuit Group
May 27–June 26, 1918	Aisne-Marne defensive (France)	2nd Division, 3rd Division
June 9–13, 1918	Montdidier-Noyon defensive (France)	1st Division
July 15–18, 1918	Champagne-Marne defensive (France)	3rd, 26th, 28th, 42nd Divisions; 369th Infantry; 66th Field Artillery Brigade; 42nd, 44th Artilleries; 1st Corps Artillery Park; 322nd Field Signal Battalion; 406th Telegraph Battalion; 1st Corps Observation Squadron; 3rd, 5th Corps Observation Groups; 1st Pursuit Group; 1st Corps Balloon Group
July 18–August 13, 1918	Aisne-Marne offensive (France)	1st Division; 2nd Division; 3rd Division; 4th Division; 26th Division; 28th Division; 32nd Division; 42nd Division; 369th Infantry; 66th Field Artillery Brigade; 1st Corps Artillery Park; 1st Gas Regiment (B & D Companies); 1st Battalion Trench Artillery; 2nd Cavalry; 308th, 322nd Field Signal Battalions; 14th, 29th, 40th, 308th Engineers; 1st Pioneer Infantry; 52nd, 406th, 411th Telegraph Battalion; 1st, 3rd, 5th Corps Observation Groups; 1st Pursuit Group; 1st, 3rd Corps Balloon Groups
August 8–November 11, 1918	Somme offensive (France)	27th Division; 30th Division; 33rd Division; 318th Field Signal Battalion; 412th Telegraph Battalion; 301st Battalion Tank Corps
August 18–September 17, 1918	Oise-Aisne (France)	28th Division; 32nd Division; 77th Division; 370th Infantry, 57th Field Artillery Brigade; 1st, 2nd Corps Artillery Parks; 55th, 56th Artilleries; 308th Field Signal Battalion; 14th, 308th Engineers; 1st Pioneer Infantry; 52nd Telegraph Battalion
August 19–November 11, 1918	Ypres-Lys offensive (Belgium)	27th Division, 30th Division, 37th Division, 91st Division, 412th Telegraph Battalion
September 12–16, 1918	Saint Mihiel offensive (France)	1st, 2nd, 3rd, 4th, 5th, 26th, 30th, 33rd, 36th, 42nd, 78th, 80th, 82nd, 89th, and 90th Divisions; others (organizations not assigned to divisions); 1st Gas Regiment (A, B, C, D, E, and F Companies)
September 26–November 11, 1918	Meuse-Argonne offensive (France)	1st, 2nd, 3rd, 4th, 5th, 6th, 26th, 27th, 28th, 29th, 30th, 32nd, 33rd, 35th, 36th, 37th, 42nd, 77th, 78th, 79th, 80th, 81st, 82nd, 89th, 90th, 91st, and 92nd Divisions, and others
October 24–November 4, 1918	Vittorio Veneto (Italy)	332nd Infantry

way to mutinies within the ranks. The British attacks on Messines Ridge, Ypres, and Cambrai failed in their primary objectives, leading to significant casualties and low unit morale (Table 2-1). Initially, the British and French primarily wanted US infantry to reinforce the lines, but General John J Pershing resisted breaking up American units and using them simply as reinforcements. The first American units, members of the AEF 1st Division, arrived in France in July 1917. Ill-prepared to use or defend themselves against chemical weapons, the American troops found gas warfare an inescapable fact of life in the trenches, with chemicals contaminating clothing, food, water, equipment, and the trenches themselves. American officers were reluctant to employ chemical agents for fear of inviting German retaliation.

### *Cambrai*

Three American engineer regiments, the 11th, 12th, and 14th, were engaged in construction activity behind British lines at Cambrai in November 1917 when they became the first AEF units to experience conditions in the trenches. (Even before the Cambrai offensive began, two AEF soldiers from the 11th Engineers became the first American battle casualties in France when they were wounded by German artillery shells on September 5, 1917.<sup>29</sup>) On November 30 German gas shelling intensified in the vicinity of the three AEF regiments. British officers ordered a withdrawal, but the AEF engineers were taken by surprise. Some hid



**Fig. 2-9.** US troops receiving gas mask instruction in 1918 before entering the trenches. 329th Infantry. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.



**Fig. 2-10.** Proper gas training to avoid becoming a casualty was routine for the American Expeditionary Forces in World War I. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

in dugouts trapped behind the German advance while others used their picks and hand tools to fight. Most of the AEF units returned to take up defensive positions to halt the German advance. Six soldiers of the 11th Engineers were killed from shelling (high explosive and gas), 11 were wounded, and 13 were taken prisoner.<sup>29</sup> These casualties were counted as British gas casualties in the final statistics because they would not



**Fig. 2-11.** US soldiers receiving instructions from French officers in early 1918 on quickly donning gas masks. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

have been funneled through American field hospitals. Cambrai represented the first participation by the AEF in active fighting.

### *Sommervillier and Ansauville*

Pershing sought an area near Lorraine where the AEF could concentrate, train in gas warfare with help from the French (Figures 2-9, 2-10, and 2-11), and eventually fight. The 1st Division trained in gas defense exercises from September 1917 to January 1918, and a preliminary gas organization was set up in the division in December 1917.<sup>30,31</sup> As it began training in the practice trenches at Gondrecourt, the division was



**Fig. 2-12.** Early American Expeditionary Forces training in 1917. American Expeditionary Forces soldier training with a bayonet while wearing the British small box respirator. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

issued both the French M-2 gas mask and the British small box respirator (Figure 2-12). The French warned the Americans about Germany's use of mustard gas and the importance of using their respirators. After additional training in the Sommervillier section in Lorraine with units of the 18th French Division, the 1st Division relieved part of the 1st Moroccan Division in the Ansauville sector, where it experienced the first reported gas attack on the AEF.

The attack took place on February 26, 1918, between 1:20 and 1:30 AM, when the Germans fired some 150 to 250 phosgene and chloropicrin projectiles against the Americans near Bois de Remieres, France (Exhibit 2-6). Some projectiles exploded in the air, others on the ground. A second, similar attack occurred about an hour later. However, a discrepancy appears in the literature over the type and number of projectors and trench mortar bombs involved. Sources state that phosgene and chlorine were employed, but contain varying accounts of the number of projectors involved.<sup>30</sup>

Although the 1st Division received the most rigorous combat and gas training of any American division, inexperience still led to mistakes. Major General Robert Bullard, head of the 1st Division, remarked on the gas training his division received at Ansauville:

Gas is such an intangible thing that men are only with great difficulty made to guard themselves against it. A state of instruction adequate against the danger is extremely hard to obtain. . . . Our gas officers were almost hysterical in their efforts to teach and impress our new troops; but knowledge and real efficient training came only after hard experience.<sup>32(p5)</sup>

The Americans suffered 85 casualties, including eight deaths—approximately a third of their battalion—in the aftermath of the attack. Although reports stated that from the time the bright lights of the crashing projectiles hit to the elaboration of gas, soldiers had no time to don either the M2 or British small box respirator, the majority of the casualties were preventable through better discipline. The lack of discipline was the result of four factors. First, some soldiers could not find their gas masks in time (Exhibit 2-7). Second, some noncommissioned officers let soldiers remove their masks too quickly, only a half hour after the last shell fell. Third, other soldiers switched from the effective but uncomfortable small box respirator to the more comfortable but less effective French M2, receiving gas in the process. Fourth, soldiers continued to work unmasked in the woods as late as 48 hours after the attack, despite the odor of phosgene in the air.<sup>33</sup> Determined not to be caught by such an attack again in the Ansauville sector, the 1st Division made

## EXHIBIT 2-6

### FIRST PROJECTOR ATTACK ON THE AMERICAN EXPEDITIONARY FORCES

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The earliest written account of an attack involving projectors and trench mortar chemical bombs on the American Expeditionary Forces occurred on February 26, 1918. A projector was a device that lobbed a football-sized gas projectile into enemy trenches. The objective was to get the gas as far from friendly forces as possible before releasing it. Two attacks involving trench mortar bombs and projectiles occurred between 1:20 and 1:40 AM. The trench mortar attack consisted of two salvos of phosgene bombs. The projectiles used were mixtures of phosgene and possibly chloropicrin, based on their odors. General Bullard stated that two volleys, each consisting of 100 18-cm shells, mostly phosgene, crashed "with a loud explosion and bright flare of light." Rudolf Hanslian and records of the 78th Reserve Division in Germany indicated a much larger gas assault by the 35th Pioneer Battalion, involving 810 projectors loaded with phosgene flasks and 10 with the new diphenylchloroarsine gas, along with 80 high explosives, to produce casualties with almost 14 tons of phosgene. This discrepancy in the number of projectiles can be explained from the accounts of two German prisoners, who deserted on March 20. They reported that 900 projectors were employed, "one half of which fell in their own front lines," keeping them out for 2 days. The 35th Pioneer Regiment never completed the elaborate raid, code-named "Einladung," that immediately followed the projector attack on the American Expeditionary Forces.

Data source: Spencer EW. *The History of Gas Attacks Upon the American Expeditionary Forces During the World War, Part I*. Edgewood Arsenal, Md: Chemical Warfare Service, US War Department; 1928: 37–51.

continuous efforts to spot projector installations and neutralize them.

#### *Lys Defensive*

General Erich Ludendorff, deputy chief of the general staff for Germany, still hoped to destroy the hard-hit British army before it had a chance to recover from the effects of the Somme drive. This was the purpose of a new German attack launched April 9, 1918, on a narrow front along the Lys River in Flanders. The Germans committed 46 divisions to the assault and

quickly scored a breakthrough. Chemical warfare with gas shells was a major component in this German offensive. These "Hutier tactics" involved brief but significant artillery shelling of enemy front and rear lines with high explosive and chemical weapons, followed by light infantry advancement. The British situation was desperate for some days, but Ludendorff called off the offensive on April 29. About 500 Americans participated in the campaign, including members of the 16th Engineers, 28th Aero Squadron, and 1st Gas Regiment.<sup>34,35</sup> Chemical casualty statistics are poor for this period; however, AEF divisions suffered higher

## EXHIBIT 2-7

### FIRST AIRPLANE GAS ATTACKS ON AMERICAN FORCES

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Although some historians erroneously state that chemical warfare involving aircraft did not occur in World War I, German forces did drop chemical bombs from airplanes during the conflict. The first gas attacks on American Expeditionary Forces from German planes took place in the village of Seicheprey, part of the 1st Division sector. Up to that point, chemical warfare involving planes had never been described. At Ansauville, a German plane dropped gas balloons, described as balls 18 inches in diameter and filled with liquid mustard, on 1st Division batteries entrenched across Hill 246 on March 19, 1918. A second airplane gas attack occurred on March 23, 1918, as part of a series of daily mustard gas attacks on the town from March 21 to March 25. American Expeditionary Forces watched a German airplane drop gas bombs over the Beaumont-Jury road and release gas balloons that exploded in the air, liberating a reddish-blue cloud. It was later reported that neither the gas balloons nor the bombs seem to have caused any casualties.

Data source: Cochrane RC. The 1st Division at Ansauville, January–April 1918; study number 9. In: *Gas Warfare in World War I. US Army Chemical Corps Historical Studies*. Army Chemical Center, Md: US Army Chemical Corps Historical Office; 1959.



**Fig. 2-13.** Members of the 26th Infantry, 2nd Brigade, 1st Division, leaving a trench to go over the top during Battle of Cantigny, May 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

chemical casualties in the early months of the war compared to the later months.

#### *First American Victory: the Battle of Cantigny*

The first sustained American offensive of the war, although a minor action, was fought between May 3 and June 8, 1918, by the AEF 1st Division under Major General Bullard. The Battle of Cantigny was part of the Third Battle of the Aisne, a large-scale German offensive to win the war before the full build-up of US troops in France. Chemical attacks inflicted major casualties on the AEF 1st Division's assault and repulsion of numerous German counterattacks (Figure 2-13). Pershing initially tasked the 18th Infantry to take Cantigny, but it was so decimated by mustard shells (around 15,000) at Villers-Tournelle between May 3 and



**Fig. 2-14.** US gas casualties from the 1st Division evacuated after the Battle of Cantigny, May 29, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

4 (when the 1st Division suffered close to 900 chemical casualties among its ranks, predominantly in the 18th Infantry, in a single night) that it was unable to carry out the mission. Consequently, Pershing charged the 28th Infantry to take Cantigny instead.<sup>36</sup> On May 28 the 1st Division captured the village of Cantigny, held by the German 18th Army and commanded and strongly fortified as a German advance observation point by General Oskar von Hutier.

Rexmond Cochrane summarizes there was a total of between 2,199 and 2,708 chemical casualties at Cantigny (Figure 2-14).<sup>36</sup> Chemical warfare played a significant role in the prelude to battle, capture, and defense of Cantigny. The number of high explosive

#### **EXHIBIT 2-8**

##### **AN ATTACK ON A PLATOON OF THE 28TH DIVISION**

An entire platoon of infantry in the 28th Division became gas casualties before reaching the front. While moving forward toward Chateau-Thierry, the soldiers stopped to rest in shallow shell craters near the road, a common occurrence, before decontaminating them. The obvious garlic smell, emanating from holes made by yellow cross shells, was diluted from recent rains. Unbeknownst to them, the holes were contaminated by mustard. The soldiers awoke with backs and buttocks so badly burned that the skin appeared to be flayed.

Data sources: (1) Spencer EW. *The History of Gas Attacks Upon the American Expeditionary Forces During the World War, Parts I-III*. Edgewood Arsenal, Md: Chemical Warfare Service, US War Department; 1928. (2) Cochrane RC. The 3rd Division at Chateau Thierry, July 1918; study number 14. In: *Gas Warfare in World War I. U.S. Army Chemical Corps Historical Studies*. Army Chemical Center, Md: US Army Chemical Corps Historical Office; 1959: 1-4, 84, 86.

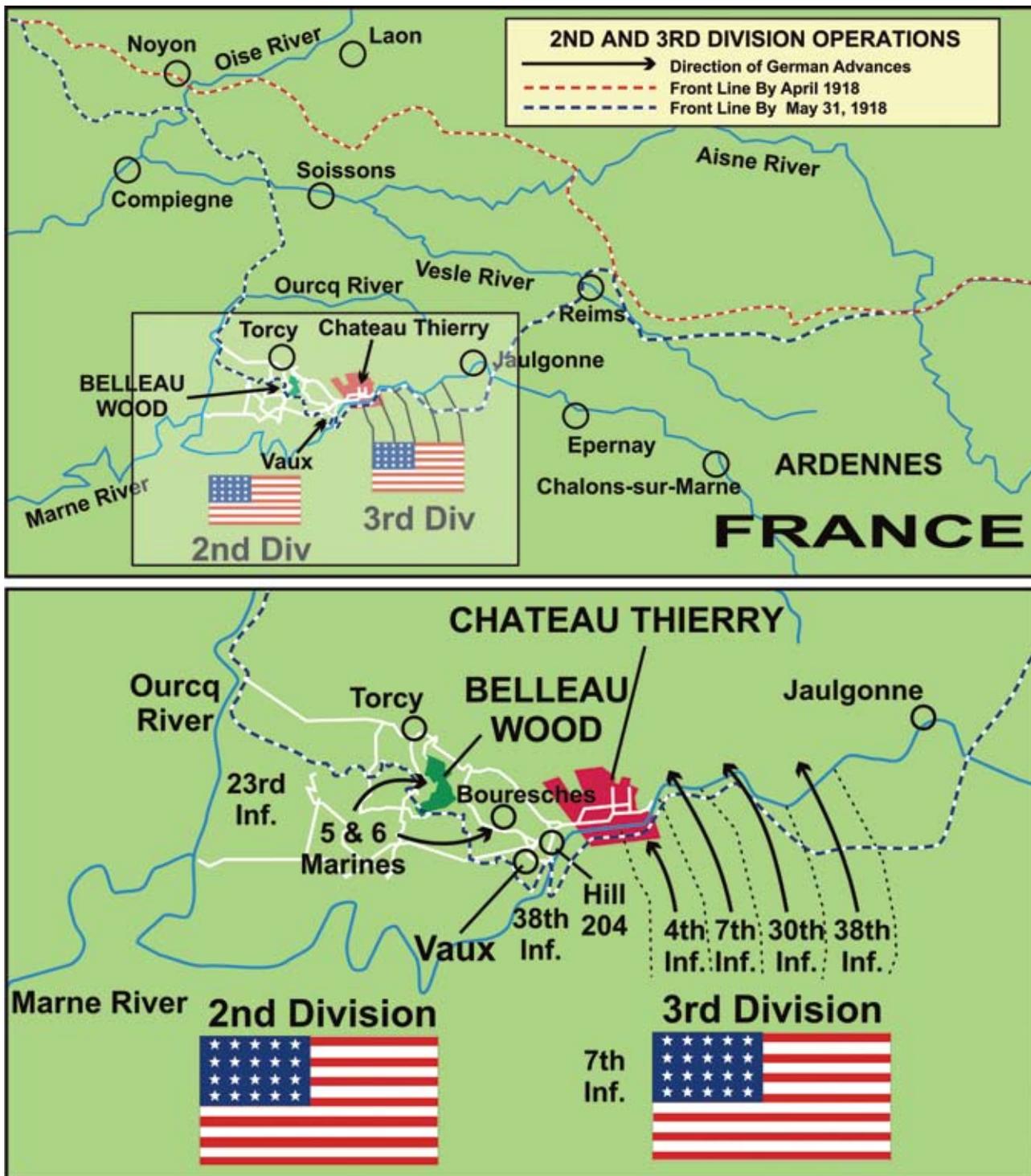
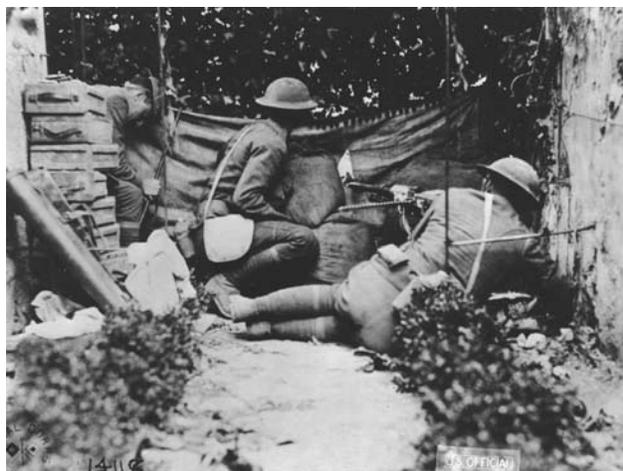


Fig. 2-15. Overview and detailed maps of 2nd and 3rd Division operations in Chateau-Thierry and Belleau Wood. Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.



**Fig. 2-16.** Company A, Seventh Machine Gun Battalion, guarding the Marne from Chateau-Thierry, France. At the time this photograph was taken, Chateau-Thierry was under bombardment from German lines across the river. June 1, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

shells used against the 1st Division was 7-fold that of gas shells, and the reported chemical and wounded casualty statistics were similar. The Germans predominantly used chlorine, bromine arsenic, mustard, and phosgene shells on the AEF at Cantigny.

### *Aisne Defensive*

The significance of the Cantigny victory was overshadowed by the battle along the Aisne, some 50 miles to the northwest, where the Germans broke through nine British and French divisions with the aid of gas and captured 50,000 Allied soldiers (Exhibit 2-8). The French and British defenders were taken by surprise, and their positions were quickly overrun on a 40-mile front. The German army progressed rapidly, capturing Aisne bridges completely intact along the way. Their thrust toward Rheims failed, but Soissons was taken, and by May 31, the German army reached the outskirts of Chateau-Thierry on the Marne, less than 40 miles from Paris (Figure 2-15). If the AEF had not quickly plugged the breach in this line at Chateau-Thierry and Belleau Wood, the Germans would have marched the 40-mile track to Paris unchallenged along the Paris-Metz Road.<sup>35,37,38</sup>

### *Chateau-Thierry*

Chateau-Thierry formed the tip of the German advance towards Paris. The AEF's 2nd and 3rd divisions



**Fig. 2-17.** US Field Artillery, 2nd Division sending over French 75-mm gas shells into the Bois de Belleau, France, during the Battle at Belleau Wood. June 30, 1918. US Signal Corps photograph. Photographs: Courtesy of US Army Military History Institute, Carlisle, Pa.

(Figures 2-16, 2-17, and 2-18) launched a counterattack on June 3–4 with the assistance of the French 10th Colonial Division. This offensive pushed the Germans back across the Marne to Jaulgonne.<sup>35,38</sup> During the defense of Chateau-Thierry, the 3rd Division suffered 1,777 chemical casualties.<sup>37</sup>

### *Belleau Wood*

The 2nd Division (5th and 6th Marine regiments) captured the Bois de Belleau Wood under heavy gas shelling, mostly mustard, from June 6 to 26. The casualties on the first day of the assault (Figure 2-19) were the highest in Marine Corps history until the capture of Japanese-held Tarawa in November 1943.<sup>35,38,39</sup>



**Fig. 2-18.** Linemen of the 5th Field Signal Brigade, 3rd Division, repair broken wire during a gas attack. Chateau-Thierry, France, June 21, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

The Germans took back the sector, which changed hands six times before the Germans were expelled. The 2nd Division suffered 3,152 chemical casualties in the Chateau-Thierry sector during the capture of Belleau Wood, Vaux, and Bouresche,<sup>39</sup> and the French renamed the wood "Bois de la Brigade de Marine," in its honor.

### *Champagne-Marne Defensive*

The Allies were prepared for the two-pronged German assault on each side of Rheims on July 15 (Figure 2-20). Plans for the attack had leaked out of Berlin, and Allied airplanes had detected unusual activity behind the enemy front. Marshal Ferdinand Foch, commander of the Allied forces, had time to draw up reserves, and Henri Philippe, the French commander, skillfully deployed his troops in defense-in-depth tactics.<sup>35,41</sup> Consequently, the German drive east of Rheims fell far short of its objective. The attack west of the city succeeded in pushing across the Marne near Chateau-Thierry once again, but was checked there by French and American units. The primary AEF units involved in this action were the 3rd and 42nd divisions, with support from the 26th and 28th divisions and the 369th Infantry.<sup>41</sup> (The 3rd Division's 38th Infantry became known as the "rock of the Marne" at this battle.<sup>35,41</sup>) The 3rd and 28th Divisions suffered 789 and 378 chemical casualties, respectively, during the defense.<sup>37</sup> The 42nd incurred the largest number of chemical casualties here



**Fig. 2-19.** Treating American gas casualties, mainly mustard, during the attack of Belleau Wood. 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

(1,246).<sup>40</sup> By July 18 the German offensive was halted once more, and the initiative passed to the Allies. The German war effort never recovered from the tremendous psychological blow of this failure.

### *Aisne-Marne Offensive*

Several days before the Germans launched their abortive Champagne-Marne drive, the French high command made plans for a general converging offensive against the Marne salient. France issued orders on July 12 for the attack to begin on the 18th, with five French armies taking part. Five divisions of the French XX Corps, accompanied by the American 1st and 2nd AEF divisions (see Figure 2-20), led the assault.<sup>35,41,42</sup> Early on July 18 the two American divisions and a French Moroccan division launched the main blow at the northwest base of the salient near Soissons. By July 28 the American contingent included the 3rd, 4th, 28th, 32nd, and 42nd divisions (see Figure 2-20). The Germans retreated across the Aisne and Vesle rivers, resolutely defending each strong point as they went. By August 6 the Aisne-Marne offensive and the German threat to Paris were over. The eight AEF divisions in the action spearheaded much of the advance, demonstrating offensive gas capabilities that helped inspire new confidence in the war-weary Allied armies (Figures 2-21 and 2-22). About 270,000 Americans took part in the battle. Heavy losses were incurred by the 3rd Division (2,146 chemical casualties) and 28th Division (1,092 chemical casualties).<sup>37</sup> The 32nd Division suffered nearly 1,300 chemical casualties in the taking of Fismes, the key to the advance from the Vesle to the Aisne River.<sup>42</sup>



Fig. 2-20. US participation in the Second Battle of the Marne. (a) Champagne-Marne defensive . (b) Aisne-Marne offensive. Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.



**Fig. 2-21.** American troops firing on German positions while under heavy gas attack in the trenches of France during the Aisne-Marne offensive. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

### *Oise-Aisne Offensive*

In mid August, the French started a series of drives on their front, which extended about 90 miles from Reims westward through Soissons to Ribecourt on the Oise River (Figure 2-23).<sup>35,43</sup> Coordinating with the British, five French armies advanced on the Somme to the north and the Americans advanced to the east. The AEF's 32nd Division and part of the French 10th Army spearheaded the penetration of the enemy's main line on August 22 and captured the town of Juvigny, a key high ground, on August 30. The 32nd completely breached the German front, forcing them to abandon the Vesle River line.<sup>35</sup> The American III Corps (28th and 77th divisions) fought with the French 6th Army east of Soissons, which, in late August, held the western part of the Vesle River sector extending from Braine to Courlandon. As the Germans retreated from the Vesle northward to the Aisne valley in early September, the III Corps took part in the aggressive pursuit operations. During the Oise-Aisne offensive, the AEF suffered 2,776 casualties, 573 of which were attributable to chemical agents.<sup>44</sup>

### *Saint Mihiel*

By September 1918, with both the Marne and the Amiens salients eliminated, one major threat to lateral rail communications behind the Allied lines remained: the old Saint Mihiel salient near the Paris-Nancy line



**Fig. 2-22.** American infantrymen of the 167th Infantry, 42nd "Rainbow" Division marching through German gas wearing Boche gas masks and box respirators near Bouvardes, France. July 29, 1918. The mounted soldiers in the counter-marching procession are French dragoons returning from patrol. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

(see Figure 2-2). American units from Flanders to Switzerland were shifted into the area near the salient.<sup>35,43,45</sup> Fourteen American and four French divisions assigned to the First Army for the operation contained ample infantry and machine-gun units for the attack; however, because of the earlier priority given to shipping infantry (at the urging of the British and French), the First Army was short of artillery, tank, air, and other support units essential to a well-balanced field army. At Pershing's insistence, this was the first major operation carried out by an independent American force, but it was subordinated to the much larger Meuse-Argonne offensive in late September.<sup>43,45</sup>

The Saint Mihiel offensive began on September 12 with a 3-fold assault on the salient. The main attack was made against the south face by two American corps. On the right was the I Corps, on the left, the

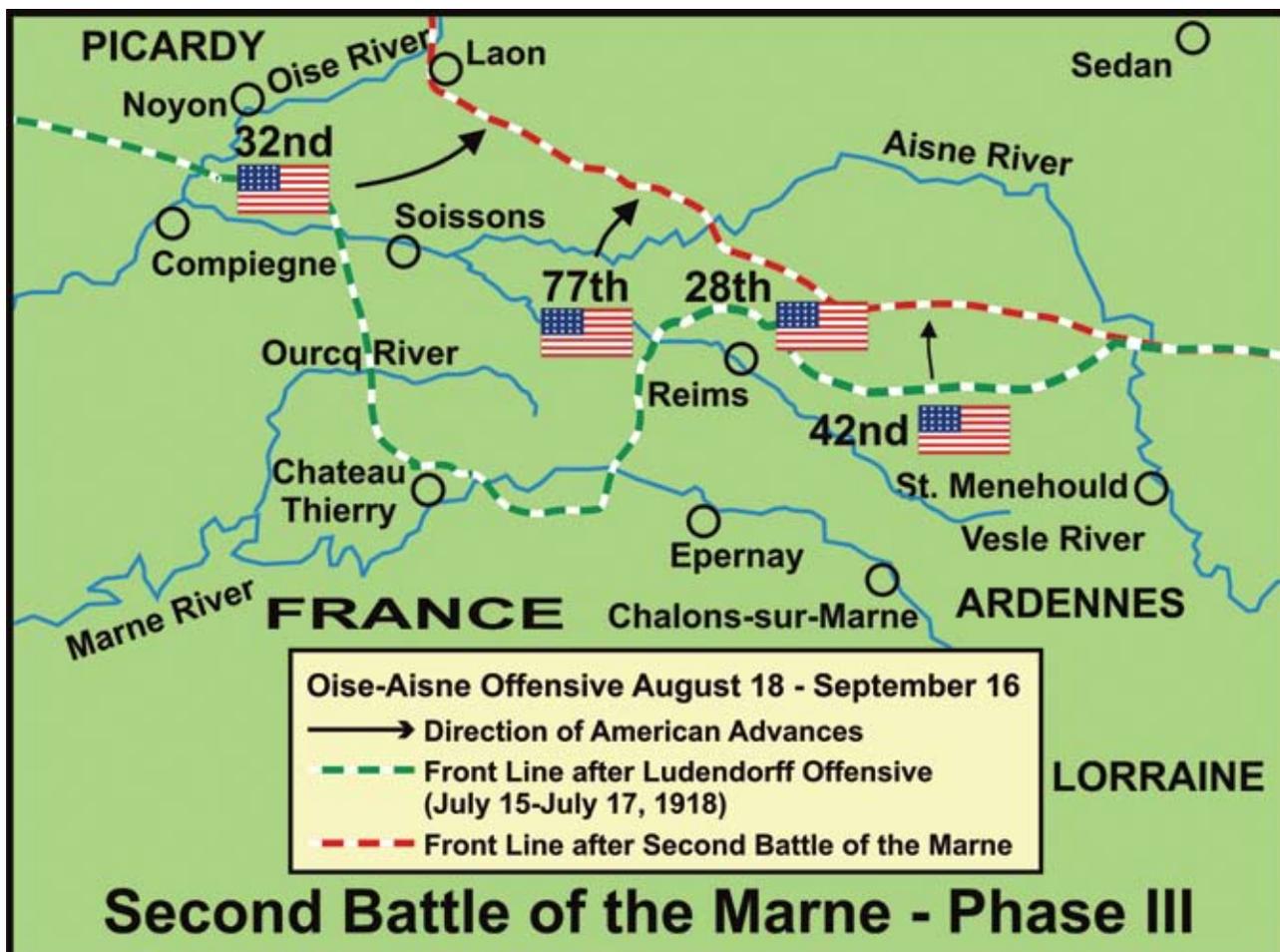


Fig. 2-23. US participation in the Oise-Aisne offensive.

Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.

IV Corps (Figure 2-24). A secondary thrust was carried out against the west face along the heights of the Meuse by the V Corps. The AEF used scant offensive gas because shelling would have negated their surprise attack, but it suffered significant casualties from German gas. Data from the division gas hospitals state that the 90th Division alone experienced 1,390 chemical casualties (460 mustard and the rest from lachrymators [tear gasses] and sternutators [sneezing agents]) during the 5-day battle, compared to 275 from the 26th Division.<sup>45,46</sup>

#### *Meuse-Argonne*

At the end of August, Marshal Foch submitted plans to the Allied commanders for a final offensive along the entire western front (see Figure 2-2, Figure 2-25). Pershing and the AEF struck a zone about 20 miles wide between the heights of the Meuse on the east

near Verdun and the western edge of the high, rough, and densely wooded Argonne Forest (Figure 2-26).<sup>38,50</sup> Pershing hoped to launch an attack with enough momentum to drive the elaborate German defense lines at Montfaucon, Cunel, and Barricourt into an open area beyond and, in a coordinated drive with the French Fourth Army on the left, effectively cut off the Sedan-Mézières railroad. The Meuse-Argonne offensive operated over four phases because of stalled gains and the replacement of exhausted and depleted divisions. By November 11, 1918, the AEF closed up along the Meuse and, east of the river, advanced toward Montmédy, Briny, and Metz, ending hostilities.<sup>35,47</sup>

General Pershing summarized the results of the Meuse-Argonne campaign, the greatest battle in American history up to that time, in his final report:

Between September 26 and November 11, 22 Ameri-



Fig. 2-24. Overview and detailed map of US participation in the Saint Mihiel offensive.  
 Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.



Fig. 2-25. Overview of Meuse-Argonne offensive.  
 Map: Courtesy of Dr Corey J Hilmas, United States Army Medical Research Institute of Chemical Defense.



**Fig. 2-26.** US infantry advancing under gas bombardment against German entrenched positions. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

can and 4 French divisions, on the front extending from southeast of Verdun to the Argonne Forest, had engaged and decisively beaten 47 different German divisions, representing 25 percent of the enemy's entire divisional strength on the western front.

The First Army suffered a loss of about 117,000 in killed and wounded. It captured 26,000 prisoners, 847 cannon, 3,000 machineguns, and large quantities of material.<sup>48</sup>



**Fig. 2-27.** American doctors treating a soldier wounded in head, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.



**Fig. 2-28.** Blinded by sulfur mustard. Gassed American Expeditionary Forces soldiers with eyes bandaged, at Field Hospital No. 13. Near Caply, France. July 2, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

Approximately 20,000 chemical warfare casualties were reported among the divisions of the First Army during the Meuse-Argonne campaign (Figure 2-27).<sup>49</sup> Gas casualties accounted for 22% of all casualties in the campaign. The 3rd Division suffered 1,237 chemical casualties, the 26th Division 1,942,<sup>46</sup> and the 33rd Division 2,400.<sup>50</sup>

### *Aftermath of Battle*

The armistice of November 1918 ended the world's first chemical war. Of the approximately 26 million casualties suffered by the British, French, Russians,



**Fig. 2-29.** An American gas casualty in the front line trenches of the Toulon Sector in France. March 21, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

Italians, Germans, Austro-Hungarians, and Americans, around a million were gas casualties. Of the total 272,000 US casualties, over 72,000, or about one fourth, were gas casualties (Figure 2-28). Of the total US gas casualties, approximately 1,200 either died in the hospital or were killed in action by gas exposure. No casualties or deaths were attributed to biological warfare, which was also used in World War I.<sup>25</sup> With the aid of the CWS, the US Army successfully recovered from its early poor performance and survived repeated toxic chemical attacks against its troops (Figure 2-29). Likewise, by the end of the war, the 1st Gas Regiment and numerous US artillery units successfully used toxic



**Fig. 2-30.** Members of the Sixth Field Artillery, first Division, in action among bursting shells near Exermont, Ardennes, France. October 4, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

chemical agents in retaliation and during offensive operations (Figure 2-30). At the end of the war, the United States had developed the best protective mask, abundant munitions, and trained troops (Figure 2-31). The CWS had 1,680 officers and 20,518 enlisted personnel controlling the Army's chemical warfare program.<sup>27</sup>



**Fig. 2-31.** Members of the Chemical Warfare Service decontaminating a typical mustard-laden shell hole near Hanlen Field, Marne, France. December 4, 1918. US Signal Corps photograph. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

**TABLE 2-2**  
**HISTORICAL SUMMARY OF CHEMICAL WARFARE AGENTS USED IN WORLD WAR I**

Type of Agent	Chemical Agent	Common Names and Shell Markings	Chemical Formula	Date Introduced	Comments
Sneezing/ vomiting, respiratory irritant, or sternutating agents	Dianisidine chlorosulphonate	Niespulver	$C_{14}H_{16}N_2O_2ClSO_3$	October 27, 1914 (Germany)	Used in Ni-Shell at Battle of Neuve-Chapelle
	Diphenyl chloroarsine	Sternite; DA; Clark I; Blue Cross	$(C_6H_5)_2AsCl$	July 10, 1917 (Germany)	Discovered in 1881 by Michaelis and LaCoste; introduced at same time as mustard gas
	Diphenyl cyanoarsine	Sternite; DC; CDA; Clark II; Blue Cross No. 1	$(C_6H_5)_2AsCN$	May 1918 (Germany)	Developed in May 1918 as an improvement over Clark I
	Ethylcarbazol		$(C_6H_4)_2NC_2H_5$	July 1918 (Germany)	Introduced at the Battle of the Marne
	Diphenylamine-chloroarsine	DM; Adamsite	$(C_6H_4)_2NHAsCl$	Never used on battle-field	Patented by Leverkusen Farbwerk in 1915; synthesized by German chemist Wieland during WWI; discovered by American chemist Major Roger Adams during war
	Phenyldichloroarsine	Sternite; Blue Cross No. 1	$C_6H_5AsCl_2$	September 1917 (Germany)	
	Ethyl dichloroarsine	Dick; ED; Blue Cross	$C_2H_5AsCl_2$	March 1918 (Germany)	First called Yellow Cross 1 but not as effective as a vesicant, later incorporated into Green Cross 3 artillery shells
	Ethyl dibromoarsine		$C_2H_5AsBr_2$	September 1918 (Germany)	Used only as a mixture with ethyl dichloroarsine in Green Cross 3
Tearing or lacrimatory agents	Methyl dichloroarsine	Methyldick; MD; Blue Cross	$CH_3AsCl_2$	Never used on battle-field	
	Ethyl bromoacetate		$CH_2BrCOOC_2H_5$	August 1914 (France)	First combat gas used in WWI
	Xylyl bromide	T-Stoff; White Cross	$C_6H_4CH_2CH_2Br$	January 1915 (Germany)	First used in artillery shells fired against Russians at Bolimov
	Benzyl bromide	Cyclite; T-Stoff; White Cross	$C_6H_5CH_2Br$	March 1915 (Germany)	
	Bromomethyl-ethyl ketone	Homomartonite; Bn-Stoff; White Cross	$CH_3COCH_2Br$	July 1915 (Germany)	
	Ethyl iodoacetate	SK (South Kensington, England)	$CH_2ICOOC_2H_5$	September 1915 (Great Britain)	Principal lacrimator used by British; first used at Battle of Loos September 24, 1915
	Benzyl iodide	Fraissite	$C_6H_5CH_2I$	November 1915 (France)	

(Table 2-2 continues)

Table 2-2 continued

	Bromobenzyl- cyanide	Camite; CN	$C_6H_5CHBrCN$	July 1918 (France)	Only tear gas manufactured by CWS in any quantity during WWI
	Chloroacetophe- none	CN	$C_6H_5COCH_2Cl$	Postwar (United States)	Discovered by Graebe in 1869
	Chloroacetone	Tonite; A-Stoff; White Cross	$CH_3COCH_2Cl$	November 1914 (France)	Substitute for ethyl bromoac- etate in hand/rifle gas gre- nades
	Bromoacetone	Martonite; BA; B- Stoff; White Cross	$CH_3COCH_2Br$	July 1915 (Germany)	
	Iodoacetone	Bretonite	$CH_3COCH_2I$	August 1915 (France)	
	Acrolein	Papite	$CH_2CHCHO$	January 1916 (France)	
	Chloropicrin	Nitrochloroform; Aquinite; PS; NC; Klop	$CCl_3NO_2$	July 1916 (Germany); August 1916 (Russia)	Lacrimator
	Phenylcarbylam- ine chloride	Phenylisocyanide chloride	$C_6H_5CNCl_2$	May 1917 (Germany)	Lacrimator
Pulmonary agents (lung irritants or choking gases)	Chlorine	Bertholite; Red Star; Chlor	$Cl_2$	April 22, 1915 (Germany)	
	Methylsulfuryl chloride	Villantite; C-Stoff	$ClSO_3CH_3$	June 1915 (Germany)	First to be successfully used in projectiles (trench mortar bombs & hand grenades)
	Ethylsulfuryl chloride	Sulvanite	$ClSO_3C_2H_5$	June 1915 (France)	
	Chlormethyl- chloroformate	Palite; K-Stoff; C- Stoff	$ClCOOCH_2Cl$	June 18, 1915 (Germany)	K-Stoff when used in shells, C-Stoff when used in trench mortars and projector bombs
	Dimethyl sulfate	Rationite; D-Stoff	$(CH_3)_2SO_4$	August 1915 (Germany)	
	Perchlormethyl- mercaptan	Carbon tetrachlorsul- fide; Clairsite	$SCCl_4$	Septem- ber 1915 (France)	Introduced at Battle of Cham- pagne; first use of gas shell by French army
	Phosgene	Carbonyl chloride; Collongite; CG; D- Stoff; White Star (Phosgene + Chlo- rine); Green Cross	$COCl_2$	December 19, 1915 (Germany), possibly earlier in May 1915 against Russia	White Star used extensively by British in 1916 Battles of the Somme

(Table 2-2 continues)

Table 2-2 continued

	Diphosgene	Trichlormethylchloroformate; Surpalite; Superpalite; Perstoff; Green Cross	$\text{ClCOOCCl}_3$	May 1916 (Germany)	First used at Verdun in retaliation of French phosgene used February 1916
	Thiophosgene	Lacrimite; Green Cross			
	Chloropicrin	Nitrochloroform; Aquinite; PS; NC; Klop	$\text{CCl}_3\text{NO}_2$	July 1916 (Germany & Allies); August 1916 (Russia)	Discovered by English chemist Stenhouse in 1848; British called it "vomiting gas"
	Phenylcarbylamine chloride	Phenyl isocyanide chloride	$\text{C}_6\text{H}_5\text{CNCl}_2$	May 1917 (Germany)	
	Dichlorodimethyl ether & dibromodimethyl ether	"Labyrinthic substances"; Bibi; Cici	$(\text{CH}_2\text{Cl})_2\text{O}$ $(\text{CH}_2\text{Br})_2\text{O}$	January 1918 (Germany)	Exerts a peculiar action on the labyrinth of the ear, altering equilibrium
	Phenyldichloroarsine	Sternite	$\text{C}_6\text{H}_5\text{AsCl}_2$	September 1917 (Germany)	The first toxic lung-injuring agent
	Ethyldichloroarsine	Dick; ED	$\text{C}_2\text{H}_5\text{AsCl}_2$	March 1918 (Germany)	
	Phenyldibromoarsine		$\text{C}_6\text{H}_5\text{AsBr}_2$	September 1918 (Germany)	
Vesicants or blister agents	Dichlorethylsulfide	Sulfur mustard; LOST; Yperite; HS; Yellow Cross	$\text{S}(\text{CH}_2\text{CH}_2)_2\text{Cl}_2$	July 12, 1917 (Germany)	
	Ethyldichloroarsine	Dick; ED	$\text{C}_2\text{H}_5\text{AsCl}_2$	March 1918 (Germany)	
	Chlorvinyl dichloroarsine	Lewisite	$\text{CHClCHAsCl}_2$	Never used on battlefield	The major American contribution to the chemical weapon inventory but never used in war time; developed by Captain Winford Lee Lewis of the CWS in 1917; Germans claim they manufactured it in 1917 prior to the American discovery
	Methyldichloroarsine	Methyldick; MD; Blue Cross	$\text{CH}_3\text{AsCl}_2$	Never used on battlefield	Discovered by Baeyer in 1858; Americans studied it intensely at the end of WWI; not used by either side
	Dibromoethyl sulfide	Brom LOST	$\text{S}(\text{CH}_2\text{CH}_2)_2\text{Br}_2$	Never used on battlefield	Studied by Germany in the closing days of the war
Systemic or blood agents	Hydrogen cyanide	Hydrocyanic acid; Vincennite; Managanite; Forestite	$\text{HCN}$	July 1, 1916 (France)	Exclusively used by French in WWI; usually mixed with other chemicals (arsenic trichloride, stannic chloride, and chloroform) to increase its stability and make it heavier

(Table 2-2 continues)

Table 2-2 continued

Cyanogen bromide	Ce (Austrians); CB (British); Campillit; Campilite; E-Stoff	CNBr	September 1916 (Austria)	
Cyanogen chloride	Vitrite; Mauginite	CNCl	October 1916 (France)	Maybe used as early as July 1916; exclusively used by French army in WWI; often mixed with arsenic trichloride
Phenylcarbylamine chloride	Phenylisocyanide chloride	C <sub>6</sub> H <sub>5</sub> CNCl <sub>2</sub>	May 1917 (Germany)	

CWS: Chemical Warfare Service

WWI: World War I

However, the potential for future chemical wars now loomed, as expressed by one US Army officer:

Gas was new and in an experimental stage throughout the war and hence the man who plans for future

defense must consider the use of gas to have been in its infancy. He must draw very few lessons for the future use of gas based on past performances. He must only use those lessons as pointing the way and not as approaching a final result. The firing of steel as shell passed its zenith with the passing of the Argonne fight. Never again will the world see such a hail of steel on battlefields, but in its place will be concentrations of gas and high explosives as much greater than the World War as that was greater than the Civil War.<sup>51(p4)</sup>

**EXHIBIT 2-9****HOW TO TELL THE GASES, BY MAJOR FAIRFAX DOWNEY, FIELD ARTILLERY**

Grandma smelled geranium,  
Started feeling kind of bum,  
Sure, you guessed the trouble right—  
Grandma whiffed some lewisite.

Don't you find my odor sweetish?  
Said flypaper to the fly.  
I smell just like chloropicrin,  
And you'll think you'd like to die.

Maud Miller on a summer day,  
Smelled the odor of new-mown hay,  
She said to the Judge who was turning green,  
"Put on your mask! That there's phosgene!"

Apple blossoms, fresh and dewy?  
Normandy and romance? Hooey!  
For the charming fragrance then known,  
Now is chloracetophenone.

Never take a chance if  
Garlic you should strongly sniff.  
Don't think Mussolini's passed,  
Man, you're being mustard-gassed.

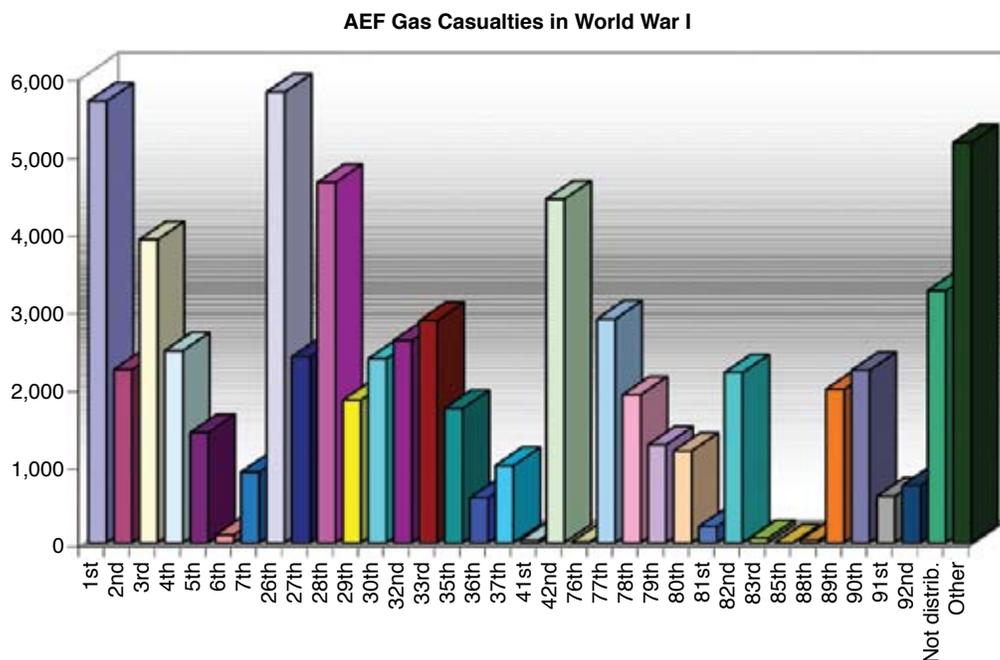
Reproduced with permission from: Waitt AH. *Gas Warfare: the Chemical Weapon, its Use, and Protection Against it*. New York, NY: Duell, Sloan, and Pearce; 1943: 4-9.

In contrast, Fritz Haber, the Nobel laureate chemist who, more than anyone else, was responsible for the development and fielding of chemical weapons for use by Kaiser Wilhelm II's army, downplayed the importance of chemical warfare as a weapon of mass destruction. In an interview published in New York in 1921, he concluded, "Poison gas caused fewer deaths than bullets."<sup>52(p10)</sup> General Pershing summed up his opinion of the new chemical warfare shortly after the conclusion of World War I, saying, "Whether or not gas will be employed in future wars is a matter of conjecture, but the effect is so deadly to the unprepared that we can never afford to neglect the question."<sup>48(p77)</sup>

A comprehensive list of chemical warfare agents used by and against the AEF during World War I, along with their dates of introduction, is provided in Table 2-2. A more humorous description of the major gases experienced by the AEF in World War I can be found in Major Fairfax Downey's poem, *How to Tell the Gases* (Exhibit 2-9).<sup>9</sup>

**American Expeditionary Forces Chemical Warfare Casualties**

Gas was responsible for approximately 2% of the deaths in World War I, but it caused considerably greater numbers of battlefield casualties (Figure 2-32). Nevertheless, it is difficult to account for the total num-



**Fig. 2-32.** American Expeditionary Forces gas casualties in World War I. Casualty statistics reflect those Americans treated in American, French, British, and Belgian field hospitals. The categories “Not Distributed” and “Other” reflect those American units not organized into divisions.

ber of gas cases in the surgeon general’s records. Base hospitals of the French and British divisions received many of the early AEF chemical casualties. Therefore, these American casualties were either not statistically recorded as chemical casualties or were counted under British or French statistics.

In addition, gas officers, who were responsible for compiling chemical casualty statistics, arrived in Europe after the first few AEF divisions. Consequently, they were unable to tally chemical casualty statistics early in the war, when lack of discipline in the trenches caused the greatest numbers of chemical casualties.

Also, chemical casualties from inhalation were difficult to prove because only pulmonary signs and symptoms were evident. Medical personnel viewed soldiers with no clear dermatological signs and symptoms as

neurotic malingerers feigning illnesses to leave the front lines. Although pulmonary intoxication from chemical weapons was common, death was often the result of influenza, a major problem in World War I. Chemical toxicity as the result of inhalational or dermal exposure to agents often led to bacterial infection and death. Base hospitals underestimated the effects of chemicals on casualties because many mortalities were tallied as death secondary to influenza, rather than from the initial chemical insult. The majority of the gas casualty reports filed included immediate deaths only (most likely due to a combination of shrapnel and gas); they often did not include deaths from gas exposure that occurred days or weeks later. Chemical shelling was also the cause of many cases of “psychoneuroses.” Food contamination from dispersed chemicals in the air was a major paranoia among World War I soldiers.

### THE 1920s

An international push to ban chemical weapons followed the conclusion of the war (see Chapter 4). Despite the treaties, rumors of chemical warfare attacks plagued the world throughout the 1920s. Besides the United States and the major World War I powers, several other countries began to develop chemical warfare capabilities, and some countries put their capabilities

into operation. During the Russian civil war and Allied intervention in the early 1920s, both sides had chemical weapons and isolated chemical attacks were reported.

Later accounts accused the British, French, and Spanish of using chemical warfare at various times during the 1920s.<sup>4,53</sup> The Berber-led resistance movement against French and Spanish colonialism in

North Africa had resulted in key victories against the Spanish army, forcing their retreat to the Moroccan coastline by 1924. The following year, France forged a counterattack with Spain to subdue the rebellion. Fighting lasted a year, with the alleged use of mustard gas by Spain and France against the Berbers, who were eventually defeated.<sup>54</sup> Also in 1924, the Italians established the Centro Chemico Militaire, a unified chemical warfare service, and began producing chemical agents, which attracted US attention.<sup>55-57</sup>

### Survival of the Chemical Warfare Service

The CWS, originally organized by the Army as a temporary war measure, was part of the National Army only, not the Regular Army. Its temporary status was due to expire within 6 months after the end of the war (later extended to June 30, 1920). However, if the CWS disbanded, the US Army would almost certainly forget the extensive experience of chemical

offense, defense, and preparedness gained during the war. During congressional hearings, Secretary of War Newton D Baker testified, "We ought to defend our army against a gas attack if somebody else uses it, but we ought not to initiate gas."<sup>58(p3)</sup> Baker and Chief of Staff General Peyton C March used this philosophy to recommend abolishing the CWS and outlawing chemical warfare by a treaty.<sup>59</sup> Even General Sibert, when asked about the need for a permanent CWS and the possibility of chemical warfare in the future, replied, "Based on its effectiveness and humaneness, [chemical warfare] certainly will be an important element in any future war unless the use of it should be prohibited by international agreement. As to the probability of such action, I cannot venture an opinion."<sup>60(p87)</sup>

Several prominent civilian and military leaders lobbied for a permanent chemical warfare organization (Figure 2-33). Lieutenant Colonel Fries, one of the strongest proponents of a permanent organization,

# U. S. CHEMICAL WARFARE SERVICE

## 1933



1

Gas Protection for Man and Horse



5

1st Chemical Regiment in the Field



2

Airplanes Lay a Smoke Screen Around Lower Manhattan



3

4-inch Stokes Mortar Firing Gas Shells



4

Laying a Smoke Curtain Around a Bombing Target

Fig. 2-33. Advertisement for the US Chemical Warfare Service. Photograph: Courtesy of US Army Military History Institute, Carlisle, Pa.

stressed the need for a central establishment, one that covered all aspects of chemical warfare. He drew on the lessons learned from the Great War, saying:

Had there been a chemical Warfare Service in 1915 when the first gas attack was made, we would have been fully prepared with gases and masks, and the Army would have been trained in its use. This would have saved thousands of gas cases, the war might easily have been shortened six months or even a year, and untold misery and wasted wealth might have been saved.<sup>61(p4)</sup>

Fries also disagreed with the premise that treaties could prevent warfare:

Researches into poisonous gases cannot be suppressed. Why? Because they can be carried on in out-of-the-way cellar rooms, where complete plans may be worked out to change existing industrial chemical plants into full capacity poisonous gas plants on a fortnight's notice, and who will be the wiser?<sup>23(p3)</sup>

Although Fries's comments were persuasive and eloquent, a young lieutenant more graphically expressed the opinion of those who understood the nature of chemical warfare in a 1919 poem:

There is nothing in war more important than gas  
The man who neglects it himself is an ass  
The unit Commander whose training is slack  
Might just as well stab all his men in the back.<sup>62(cover iv)</sup>

Proponents for a chemical warfare service won the debate. On July 1, 1920, the CWS became a permanent part of the Regular Army. Its mission included developing, procuring, and supplying all offensive and defensive chemical warfare material, together with similar functions in the fields of smoke and incendiary weapons. In addition, the CWS was made responsible for training the Army in chemical warfare and for organizing, equipping, training, and employing special chemical troops.<sup>27,63</sup>

### Lean Years for the Chemical Warfare Service

Despite having gained permanent status, the years after 1920 were lean ones for the CWS and the Army as a whole. The CWS was authorized 100 Regular Army officers but never actually achieved that number. The low point was 64 officers in 1923. Enlisted strength dropped to a low of 261 in 1919 and averaged about 400 the rest of the decade. Civilian employees numbered less than a thousand. The low point in funds was in 1923, when the budget was \$600,000.<sup>27</sup>

After 1919 almost all the work of the CWS moved to Edgewood Arsenal, Maryland, with only the headquarters remaining in Washington, DC. Edgewood became the center of training, stockpiling, and research and development. Initially, the CWS was authorized to train only its own troops in all aspects of chemical warfare while other Army elements were permitted defensive training only. The CWS protested this limitation and finally in May 1930, the judge advocate general ruled that both offensive and defensive training was allowed for all troops.<sup>64</sup>

Leftover stocks of chemicals from World War I were deemed sufficient for the Army's stockpile. In 1922, to comply with the Limitation of Arms Conference, the War Department ordered that "the filling of all projectiles and containers with poisonous gas will be discontinued, except for the limited number needed in perfecting gas-defense appliances."<sup>65</sup> The CWS was only allowed to continue limited research and development based on predictions of future wars.<sup>65,66</sup>

At the close of the 1920s, the CWS formalized the standardization of chemical agents. Seven chemical agents and smokes were selected as the most important. The seven, with their symbols, were as follows:

- mustard agent (HS; "H" for Hun-Stoffe, "S" for the 25% solvent added to form crude mustard. "D" later replaced the "S," signifying distilled or purified mustard);
- methyldifluorarsine (MD);
- diphenylaminechlorarsine (DM);
- chloroacetophenone (CN);
- titanium tetrachloride (FM);
- white phosphorus (WP); and
- hexachlorethane (HC).

Phosgene (CG) and lewisite (L) were considered less important. Chloropicrin (PS) and chlorine (Cl) were rated the least important.<sup>4</sup>

### New US Policy

Further international attempts to ban not only the use of chemical weapons but also all research, production, and training elicited a response that developed into a new US policy on chemical warfare. Army Chief of Staff General Douglas MacArthur stated the policy in a letter to Secretary of State Henry L. Stimson in 1932:

In the matter of chemical warfare, the War Department opposes any restrictions whereby the United States would refrain from all peacetime preparation or manufacture of gases, means of launching

gases, or defensive gas material. No provision that would require the disposal or destruction of any existing installation of our Chemical Warfare Service or of any stocks of chemical warfare material should be incorporated in an agreement. Further-

more, the existence of a War Department agency engaged in experimentation and manufacture of chemical warfare materials, and in training for unforeseen contingencies is deemed essential to our national defense.<sup>59(p118)</sup>

## THE 1930s: GROWING THREAT OF CHEMICAL WARFARE

The use of chemical weapons in the name of imperialist expansion awakened the international community during the 1930s, when Italy and Japan deployed their offensive chemical stockpiles against unprotected neighbors. In addition, a new chemical threat emerged with the discovery of nerve agents, poisons of extraordinary potency, by Dr Gerhard Schrader in Germany. While some countries used chemical weapons, others stockpiled them. No international attempts to ban chemical warfare occurred during the 1930s.

### Italian-Ethiopian War

The first major use of chemical weapons after World War I came in 1935 during the Italian-Ethiopian War. Italy's fascist dictator, Benito Mussolini, launched an invasion of Ethiopia from its neighbors Eritrea, an Italian colony, and Italian Somaliland, that lasted approximately 7 months starting October 3. Viewed as a prelude to World War II, the Italian-Ethiopian War proved the effectiveness of chemical weapons and the ineffectiveness of the League of Nations.

Ethiopia protested the invasion to the League of Nations, which in turn imposed limited economic sanctions on Italy. These sanctions, although not crippling, put pressure on Italy to either win the war or withdraw. The initial Italian offensive from Eritrea was not pursued with enough vigor in Mussolini's opinion, and the Italian commander was replaced. The new commander, Marshal Pietro Badoglio, was ordered to finish the war quickly. He resorted to chemical weapons to defeat the Ethiopian troops led by Emperor Haile Selassie. Despite the Geneva Protocol of 1925, which Italy had ratified in 1928 (followed by Ethiopia in 1935), the Italians dropped mustard bombs and occasionally sprayed mustard from airplane tanks. They also used mustard agent in powder form as a "dusty agent" on the African desert sands to burn the unprotected feet of the Ethiopians. There were rumors of phosgene and chloropicrin attacks, but these were never verified. The Italians attempted to justify their use of chemical weapons by citing the exception to the Geneva Protocol restrictions that referred to acceptable use for reprisal against illegal acts of war, stating that the Ethiopians had tortured or killed their prisoners

and wounded soldiers.<sup>67-79</sup>

The chemical weapons devastated the unprepared and unprotected Ethiopians, who had few anti-aircraft guns and no air force. Selassie described the situation to the League of Nations:

Special sprayers were installed on board aircraft so they could vaporize over vast areas of territory a fine, death-dealing rain. Groups of 9, 15, or 18 aircraft followed one another so that the fog issuing from them formed a continuous sheet. It was thus that, as from the end of January 1936, soldiers, women, children, cattle, rivers, lakes, and pastures were drenched continually with this deadly rain. In order more surely to poison the waters and pastures, the Italian command made its aircraft pass over and over again. These fearful tactics succeeded. Men and animals succumbed. The deadly rain that fell from the aircraft made all those whom it touched fly shrieking with pain. All those who drank poisoned water or ate infected food also succumbed in dreadful suffering. In tens of thousands the victims of Italian mustard gas fell.<sup>72(pp151-152)</sup>

By May 1936 Italy's army had completely routed the Ethiopian army. Italy controlled most of Ethiopia until 1941, when British and other allied troops reconquered the country. The US Army closely followed the war and sent Major Norman E Fiske to observe with the Italian army, and Captain John Meade to observe with the Ethiopian army. Their different conclusions as to the role of chemical warfare in the conflict reflected the sides they observed. Major Fiske thought the Italians were clearly superior and that victory for them was assured. The use of chemical agents in the war was nothing more than an experiment. "From my own observations and from talking with [Italian] junior officers and soldiers," Fiske reported, "I have concluded that gas was not used extensively in the African campaign and that its use had little if any effect on the outcome."<sup>77(p20)</sup> His opinion was supported by others who felt that the Ethiopians had made a serious mistake in abandoning guerrilla operations for a conventional war.

On the other hand, Captain Meade thought that chemical weapons were a significant factor in winning the war. They had been used to destroy the morale of the Ethiopian troops, who had little or no protection,

and to break up any attempts at concentrating forces. "It is my opinion that of all the superior weapons possessed by the Italians, mustard gas was the most effective," Meade said. "It caused few deaths that I observed, but it temporarily incapacitated very large numbers and so frightened the rest that the Ethiopian resistance broke completely."<sup>77(p20)</sup>

Major General JFC Fuller, also assigned to the Italian army, highlighted the Italian use of mustard agent to protect the flanks of columns by denying ridgelines and other key areas to the Ethiopians. He said that "in place of the laborious process of picketing the heights, the heights sprayed with gas were rendered unoccupiable by the enemy, save at the gravest risk. It was an exceedingly cunning use of this chemical."<sup>74(p143)</sup>

Still another observer stated:

I think [where mustard] had [the] most effect was on animals; the majority of the Ethiopian armies consisted of a number of individual soldiers, each with his donkey or mule on which he carried rations. These donkeys and mules ate the grass and it killed them, and it was that which really broke down morale more than anything.<sup>75(p81)</sup>

BH Liddell Hart, another military expert, reconciled the two schools of thought, concluding that "the facts of the campaign point unmistakably to the conclusion that mechanization in the broad sense was the foundation on which the Italians' military superiority was built, while aircraft, the machine gun, and mustard gas proved the decisive agents."<sup>76(p330)</sup>

All observers seemed to agree that the Italian military superiority would eventually have won, whether chemical agents were used or not. In general, the US Army learned little from this war. The CWS annual report for 1937 stated that "situations involving the employment of chemical agents have been introduced into a greater number of problems."<sup>78</sup> The CWS Chemical Warfare School concluded that "the use of gas in Ethiopia did not disclose any new chemical warfare tactics,"<sup>79</sup> but only reconfirmed existing tactical use expectations. One senior Air Corps officer, perhaps noting Italy's successful use of spray tanks, commented on the school's class for Army Air Corps personnel, "We want that course repeated again and again until all of our people are thoroughly awake to the necessity for training and preparation."<sup>80(p153)</sup>

### Japanese Invasion of China

The next war that drew the interest of chemical warfare experts began when the Japanese invaded China in 1937. In addition to their biological warfare

program, the Japanese had an extensive chemical weapons program and produced agent and munitions in large numbers by the late 1930s. During the war with China, Japanese forces reportedly began using chemical shells, tear gas grenades, and lacrimatory candles, often mixed with smoke screens. By 1939 the Japanese had reportedly escalated to using mustard agent and lewisite. The weapons proved effective against the untrained and unequipped Chinese troops. The Chinese reported that their troops retreated whenever the Japanese used smoke, thinking it was a chemical attack.<sup>53,81</sup>

### Organophosphorus Compounds

After the Italian-Ethiopian War, the possibility of war in Europe became the primary concern of the US Army. The CWS closely studied the chemical warfare capabilities of Germany and Italy, but it clearly overlooked the secret German development of nerve agents. Although largely isolationist in policy, the United States began gradually increasing its military posture because of the deteriorating political situation in Europe. Official policy, however, remained against the employment of chemical warfare, and initially the CWS met with much resistance. Public opinion continued to be solidly opposed to any chemical weapon use, and President Franklin D Roosevelt refused to permit the redesignation of the CWS as a "corps" in 1937. The US Army chief of staff finally approved two CWS battalions just before the beginning of World War II.<sup>59</sup>

While Italy and Japan employed conventional chemical weapons during their respective invasions, Germany pioneered new chemical warfare technology through the development of nerve agents. The history of nerve agent development had its roots with the Calabar bean, used initially as an ordeal poison in witchcraft trials by African tribal peoples,<sup>82-84</sup> and later used medicinally.<sup>85</sup> By 1864 the active compound, isolated by Jobst and Hesse, was termed "physostigmine."<sup>82</sup> This is the earliest use of a substance that works like a nerve agent through inhibition of the enzyme cholinesterase. Physostigmine, a member of the carbamate class of reversible cholinesterase inhibitors, was separately isolated in 1865 by Vee and Leven and called "eserine."<sup>82</sup>

The first organophosphorus (OP) cholinesterase inhibitor was tetraethyl pyrophosphate, synthesized by Wurtz and tested by Clermont in 1854.<sup>86</sup> Later chemists made contributions to the science of OP compounds,<sup>87-90</sup> but the toxic nature of such compounds was unrealized until the 1930s, when an investigation into both

**EXHIBIT 2-10****ORGANOPHOSPHORUS  
CATEGORIZATION**

Altogether, there are five organophosphorus compounds recognized as nerve agents, designated GA (tabun), GB (sarin), GD (soman), GF (cyclosarin), and VX by their North Atlantic Treaty Organization military abbreviation. The "G" series is so named because these compounds originated in Germany. The A through F designation was based on the chronological order of synthesis of each agent. Soman was termed GD rather than GC because the latter acronym had already been established in the medical literature, possibly reserved for gonococcus. GF was the fourth agent synthesized, but interest in this nerve agent declined in favor of the other organophosphorus compounds. The fifth agent (VX) was named for being venomous and was synthesized many years later at Porton Down, England, in 1952. Only tabun, sarin, and soman were categorized as the "Trilon group." The toxicity and lethality of these three nerve agents on the civilian population can be approximated based on their lethal doses. The lethal dose for oral ingestion of tabun is roughly 100 to 200 mg min/m<sup>3</sup>, and 50 to 100 mg min/m<sup>3</sup> for sarin. Only 200 to 1000 mg of tabun applied to the skin is sufficient to kill an adult human. The 12,000 tons of tabun stocks alone that were reported at the end of the war could kill 60 billion individuals.

Data source: *German Munition Plants and Depots During World War II*. Aberdeen Proving Ground, Md: US Army Chemical and Biological Defense Command; 1996.

carbamate-type (eg, physostigmine-type, reversible) and OP-type (irreversible) cholinesterase inhibitors led to a series of monumental discoveries by German scientists (Exhibit 2-10).

The earliest reported incident of OP toxicity from inhalation came from the laboratory of Willy Lange at Friedrich Wilhelms University. In 1932 Lange and his student, Gerde von Krueger, prepared dialkyl monofluorophosphates and noted their toxic fumes.<sup>84,86</sup> They described the effects of the vapors on themselves, reporting breathing difficulties and blurred vision that lasted many hours before subsiding. Toward the close of 1936, at the chemical and pharmaceutical conglomerate IG Farbenindustrie, Gerhard Schrader accidentally discovered powerful OP compounds during his investigation into new insecticides. After preparing them, Schrader's biologist colleague, Hans Kukenthal, tested them for insecticidal activity. On De-

ember 23, 1936, Kukenthal tested the new compounds on leaf lice and noted one to be particularly potent. All of the insects died after being sprayed with a concentration of only one part in 200,000 of the deadly substance.<sup>20,84</sup> During preliminary manufacture of the compound, Kukenthal noticed its equally impressive effects in humans. A spilled droplet from a solution could constrict the pupils and cause labored breathing immediately. Even Schrader and his colleague felt the effects upon themselves, requiring several weeks to recover. This was the first of the nerve agents or gases, called "tabun."

In 1936 tabun was reported to the chemical weapons section of the German military prior to patenting. As a colorless, odorless poison, tabun was an ideal chemical weapon. In May 1937 Schrader demonstrated its deadly effects to Colonel Rüdiger, a German ordnance officer and director of the Heereswaffenamt (HWA [German army weapons agency]). The military was impressed with the effects of the compound on the nervous system and classified the project for further research. The military assigned various names to the new substance, including "Trilon-83," "Le100," "Präparat 9/91," "Nr 100," "Gelan," "Grünring 3," "Stoff 83," and "Stoff 100," but tabun was the name that stuck.<sup>20,91</sup> After World War II, the CWS designated it "GA," for "German agent A."

During a 2-year period between 1937 and 1939, the HWA assigned a large number of chemists to evaluate tabun and work on developing new nerve agents.<sup>4,92,93</sup> The next step was mass production by the military, so the HWA built a test plant in Münsterlager. Schrader filed a patent on August 2, 1938, but it was kept secret until September 1951.<sup>94</sup> Schrader continued to synthesize esters of fluorophosphoric acid, including diisopropyl fluorophosphate, which Lange and Krueger had synthesized in 1932 and 1933.

On December 10, 1938, 2 years after the discovery of tabun, Schrader discovered a second lethal agent. This nerve agent was initially designated "T-144," the building number at the Dyhernfurth plant responsible for its pilot production.<sup>20</sup> It also went by the codenames "Le 213," "Trilon-46," and "Grünring 4."<sup>20,91,95</sup> The compound was eventually dubbed "sarin" after the four individuals involved in the initial production process (Gerhard Schrader, Otto Ambros [IG Farben board member], Colonel Rüdiger [HWA], and Hans-Jürgen von der Linde [HWA]). Some believe the "R" is named for fellow German chemist Franz Ritter.<sup>95,96</sup> Animal testing showed sarin to be five to ten times as lethal as tabun. As the second nerve agent to be synthesized, sarin was later designated "GB," for "German agent B," by the United States.

## WORLD WAR II

The start of World War II in 1939 and the rapid collapse of France in the spring of 1940 stimulated a major increase in the rate of American rearmament. No major use of chemical agents occurred, but rumors and reports of incidents of chemical warfare attracted the attention of intelligence officers. The possibility that massive chemical attacks could happen any day kept CWS officers pushing for preparedness. A newspaper article reflected the common prediction circulating in the press, saying, "European military authorities have predicted that gas would be used in the present war, if at any time the user could be sure of an immediate and all-out success from which there could be no retaliation."<sup>97(p37)</sup> Major General William N Porter, the new chief of the CWS, warned that Hitler was likely to use chemical weapons "at any moment." He also felt that "no weapon would be too bad to stop or defeat Hitler,"<sup>98(p31)</sup> and wanted to "fight fire with fire in the event an enemy chooses to use poison gas."<sup>99(p36)</sup>

Although much of Germany's and Japan's chemical weapons programs did not become known until after the war, their actual threat was impressive. Building on its experience in chemical agent use in China, Japan produced about 8,000 tons of chemical agents during the war, loading mustard agent, a mustard-lewisite mixture, and phosgene in shells and bombs and HCN into glass grenades and mortar and artillery shells. This effort was dwarfed by the German capability.

### German Production

During the war, Germany produced approximately 78,000 tons of chemical warfare agents, including about 12,000 tons of tabun between 1942 and 1945 and about 1,000 lb of sarin by 1945. Key nerve agent weapons were the 105-mm and 150-mm shells, the 250-kg bomb, and the 150-mm rocket. The latter held 7 lb of agent and had a range of about 5 miles when fired from the six-barrel Nebelwerfer launcher. Mustard agent was produced in the greatest volume and used to fill artillery shells, bombs, rockets, and spray tanks. Phosgene, of somewhat less importance, was loaded in 250-kg and 500-kg bombs. About 2,000 tons of nitrogen mustards were produced and used in artillery shells and rockets. Germany also captured a large amount of chemical munitions from France, Poland, the Soviet Union, Hungary, and other occupied countries.<sup>4,28</sup>

Germany began constructing extensive factories in Germany (Raubkammer, Falkenhagen) and later Poland (Dyhernfurth) for the massive production of tabun, sarin, cyanogen chloride, hydrocyanic acid, and N-Stoff (chlortrifluoride).<sup>20,96,100,101</sup> Just as scientists in

Berlin prepared the first samples of sarin, the German army launched its invasion of Poland in September 1939. Hitler's speech in Danzig on September 19, 1939, alluded to Germany's new weapons of war, against which enemies would be defenseless. Although the construction had begun earlier, full capacity production of the first toxic agents did not begin until May 1943.<sup>102</sup> The third and most deadly nonpersistent nerve agent, soman, was synthesized in 1944 by Richard Kuhn, a research director at the Max Planck Institute for Medical Research in Heidelberg. Soman is suggested to have been named after either the Greek word for "sleep" or the Latin word for "bludgeon."<sup>84</sup>

The resources, organization, and quality of chemists thrust into this top secret mission to synthesize nerve agents, develop new ones, and provide countermeasures against their devastating effects was on par with the American team of physicists working on the Manhattan Project. Tons of nerve agent munitions were synthesized and stockpiled in Germany during World War II, and neither the United States nor Great Britain were aware of them at the time. Meanwhile, no country on the Allied side possessed a weapon that could match the lethality of nerve gas.

### British Development of Nerve Agents

While Germany was a decade ahead in the race to synthesize nerve agents, British scientists Bernard Charles Saunders and Hamilton McCombie stumbled upon the toxic effects of esters of monofluorophosphoric acid.<sup>104</sup> Diisopropyl fluorophosphate, a lethal inhalant, was of particular interest to Saunders and McCombie. Saunders reported his findings on the toxicity of diisopropyl fluorophosphate to the Ministry of Supply in London on December 11, 1941. Among the findings were pupillary constriction and a fast onset of action. The first American report on the mechanism of action by diisopropyl fluorophosphate came out immediately after the war.<sup>105</sup> Nevertheless, tons of nerve agent munitions were synthesized and stockpiled in Germany during World War II, and neither the United States nor Great Britain were aware of them at the time. Meanwhile, no country on the Allied side possessed a weapon that could match the lethality of nerve gas.

### Why Germany Did Not Authorize Use of Chemical Weapons

The reason Hitler did not give an order to use nerve agents in World War II, a major blunder for Germany, remains a mystery. Nerve agents could have altered the

course of the war, slowing the Allied D-Day invasion by several months, enough time for the introduction of long-range V-weapons to Great Britain. Hitler decided early in the war not to use chemical weapons on the battlefield because he initially wanted peace more than he wanted to wipe out targets. When he finally thought about using them late in 1944, he no longer possessed the air supremacy to drop poison gas bombs. The reverse scenario was true for the British, who had the means to deliver gas on the Germans. Early in the war, the British did not have enough stock produced to support a gas war. By the time they had the stocks of weapons to slow the blitzkrieg in 1944, the British were already on the offensive with air supremacy and gas could only hamper their march into France and Germany.

A popular explanation for Germany's reluctance to use gas is that Hitler, a victim of a chlorine gas attack during World War I, disliked poison gas and would only use chemical agents as a last resort. Hitler was wounded on at least two occasions in World War I when he served as a dispatch runner with the rank of corporal. In *Mein Kampf*, Hitler described his own gas experience after being blinded by a mustard gas attack in Flanders at the third battle of Passchendaele:

In the night of October 13, the English gas attack on the southern front before Ypres burst loose; they used yellow-cross gas, whose effects were still unknown to us as far as personal experience was concerned. In this same night I myself was to become acquainted with it. On a hill south of Wervick, we came on the evening of October 13 into several hours of drumfire with gas shells which continued all night more or less violently. As early as midnight, a number of us passed out, a few of our comrades forever. Toward morning I, too, was seized with pain which grew worse with every quarter hour, and at seven in the morning I stumbled and tottered back with burning eyes; taking with me my last report of the War.

A few hours later, my eyes had turned into glowing coals; it had grown dark around me. Thus I came to the hospital at Pasewalk in Pomerania, and there I was fated to experience—the greatest villainy of the century.<sup>106(p118-119)</sup>

When Germany surrendered, Hitler was angry, feeling that his physical pain and the deaths of his comrades were suffered in vain. However, he never states an aversion to the use of gas.

Hitler also alluded to Germany's potential to use nerve agents in public speeches. Hitler's actions and words did not give the perception that he was afraid to use nerve agents, despite his negative personal experiences with gas on the battlefields of World War

I. Furthermore, Hitler ordered the output from the nerve agent factories to increase in 1943, despite the limited availability of material required to synthesize the agents. Hitler dedicated extensive resources to filling shells with nerve agents for his army and air force.

Others speculate that the German high command mistakenly believed the Allies had developed the nerve agents simultaneously and feared Allied retaliation as the Axis retreated. Albert Speer, the chief architect in Nazi Germany and minister of armament in Hitler's cabinet, and Otto Ambros were called to Hitler's eastern front headquarters in May 1943 and again in 1944 to discuss the use of gas. Ambros and Speer argued against gas. Ambros believed that the Allies could produce more traditional chemical agents than Germany. When later addressing the Nuremberg War Crimes Tribunal, Ambros said that he warned Hitler about using nerve agents.<sup>107</sup> Ambros's affidavit regarding his conversation with Hitler stated that the formulas for tabun and sarin were already known by the Allies because the nature of nerve agents had been disclosed in technical journals dating back to 1902. He said, "I have justified reasons to assume that tabun, too, is known abroad. I know that tabun was publicized as early as 1902, that Sarin was patented, and that these substances appeared in patents."<sup>107(p1044)</sup>

Ambros was aware that the Americans knew the basic precursor compounds in the years prior to the war but had not appeared to continue work in the field. The Germans may have speculated this was an attempt at censorship and a further indication that the United States had developed an arsenal equal to that of Germany. Ambros argued that assumption caused Germany to shelve nerve agents, a costly decision in light of Allied knowledge regarding nerve agents at the time. In reality, scientists at Edgewood Arsenal and Porton Down (Edgewood's British counterpart) did not know about either agent nor about the German antidote, atropine. It is unknown whether Ambros was telling the truth about his meeting with Hitler, but it is now known that tabun was kept secret until 1951 and sarin was never patented.

In his Nuremberg testimony, Speer pointed to Paul Joseph Goebbels, Hitler's propaganda minister, and Robert Ley, a former chemist and head of the German Labor Front, as the main proponents of gas. Martin Bormann, head of the Nazi party chancellery and Hitler's private secretary, and Hermann Ochsner, commanding general of all German chemical troops, were other prominent figures who advocated the instigation of chemical warfare against the Allies. When Speer was questioned about proposals to use poison gas warfare, he responded:

I was not able to make out from my own direct observations whether gas warfare was to be started, but I knew from various associates of Ley's and Goebbels' that they were discussing the question of using our two new combat gases, Tabun and Sarin. They believed that these gases would be of particular efficacy, and they did in fact produce the most frightful results. We made these observations as early as the autumn of 1944, when the situation had become critical, and many people were seriously worried about it. . . . All sensible army people turned gas warfare down as being utterly insane, since, in view of their [the Allies] superiority in the air, it would not be long before it would bring the most terrible catastrophe upon German cities.<sup>108(pp527-528)</sup>

Speer also cites his concerns about protecting the German soldiers from the effects of nerve agents. On the question of nerve agent production, effects, and preparations made for use in the war, Speer shed light on the implementation of possible German plans:

I cannot tell you that in detail. I am not enough of an expert. All I know is that these two gases both had a quite extraordinary effect, and that there was no respirator, and no protection against them that we knew of. So the soldiers would have been unable to protect themselves against this gas in any way. For the manufacture of this gas we had about three factories, all of which were undamaged and which until November 1944 were working at full speed. When rumors reached us that gas might be used, I stopped its production in November 1944. I stopped it by the following means. I blocked the so-called preliminary production, that is, the chemical supplies for the making of gas, so that the gas-production, as the Allied authorities themselves ascertained, after the end of December to the beginning of January, actually slowed down and finally came to a standstill. Beginning with a letter which is still in existence and which I wrote to Hitler in October 1944, I tried through legal methods to obtain his permission to have these gas factories stop their production. The reason I gave him was that on account of air raids the preliminary products, primarily cyanide, were needed urgently for other purposes. Hitler informed me that the gas production would have to continue whatever happened, but I gave instructions for the preliminary products not to be supplied any more.<sup>108(p527)</sup>

Despite nerve agent testing, manufacture, and stockpiling by the German military during World War II, chemical weapons were never deployed. Many argue that the Nazi philosophy of blitzkrieg accounted for the reluctance to use nerve agents:<sup>109</sup> a quick striking offense with tanks would only be slowed by an engagement using poison gas. The lessons Germany learned about chemical warfare from World War I were

3-fold. First, trench warfare necessitated the use of gas to break a stalemate, but gas led to only minimal gains in territory. Second, gas was more advantageous to defensive positions. Third, large advances were possible with lightning strikes using tanks and a highly mobile military, and this strategy would allow fewer casualties by overwhelming the opponent at the point of attack. Advancing into an area covered with persistent agents would hinder the mission. However, one could argue that defensively drenching the beaches of Normandy with nerve agent might have slowed the Allied D-Day invasion until the arrival of reinforcements. After the war, General Omar Bradley admitted his dread about such a defense, saying, "When D-Day finally ended without a whiff of gas, I was vastly relieved. For even a light sprinkling of persistent gas on Omaha Beach would have cost us our footing there. [Gas would have] forced a decision in one of history's climactic battles."<sup>110(p237)</sup>

### Capture of German Facilities and Scientists

Upon capture of a German ammunition dump in April 1945 (Figures 2-34 and 2-35), Allied scientists at Porton Down became aware of German tabun gas and its physiological effects for the first time.<sup>111</sup> Only then did the Allied command believe in the existence of Hitler's new "war gas," despite intelligence gathered from a captured German scientist on May 11, 1943, in Tunisia. The captured chemist worked at the nerve agent laboratory at Spandau and provided valuable informa-



**Fig. 2-34.** Storage of approximately 2,000 German tabun bombs shipped into Schierling Chemical Depot after the occupation of West Germany by American troops in the aftermath of World War II. Photograph: Courtesy of Chemical and Biological Defense Command Historical Research and Response Team, Aberdeen Proving Ground, Md.



**Fig. 2-35.** Decontamination of weaponized nerve agents after World War II. The sequence depicts a Green Ring 3 tabun-filled aerial bomb about to be vented, drained, and decontaminated. May 1946. (a) Team members pour a mixture of sodium hydroxide and bleach into a pit. (b) The pit that will contain the fully decontaminated tabun as it drains from the bomb. Photograph: Courtesy of Chemical and Biological Defense Command Historical Research and Response Team, Aberdeen Proving Ground, Md.

tion about tabun.<sup>20,103</sup> Other captured German chemists also revealed the existence of the antidote, atropine.

Kuhn, who had discovered soman, was taken into custody when American troops arrived in Heidelberg. After initially denying any involvement in military research,<sup>103</sup> Kuhn told interrogators that all documents concerning soman were buried in an abandoned mine shaft east of Berlin. The Soviet army entered Berlin before the Americans and the documents were recovered by Soviet Colonel VA Kargin, who took them back to the Karpov Institute in Moscow.<sup>20,103</sup> Capturing the prized soman documents in Berlin was a major coup. The

Soviet army also captured factories producing tabun and sarin, in addition to extensive documentation on the agents' research and manufacture.<sup>20,103,109</sup> The Soviets reassembled one of the German factories in Russia, resuming production of tabun and sarin by 1946.

Eisenhower's decision not to enter Berlin before the Soviet army seemed costly in terms of the German facilities and intelligence captured by the Soviet Union; however, the Allies capture of the majority of German scientists may have been a larger prize. The organized capture and detainment of German military scientists at Krasberg Castle was known as Operation Dustbin. Notable captured Germans included most of the chemists and technicians from Dynhernfurth, Heinrich Horlein, Gerhard Ehlers, Wilhelm Kleinhans, Werner von Braun, Albert Speer, Richard Kuhn, Walter Hirsch, Otto Ambros, and Gerhard Schrader. The Allies also captured coveted documents relating to the large-scale manufacture of nerve agents. Just prior to the fall of Falkenhagen, its director hid thousands of documents concerning Dyhernfurth, laboratory notebooks, and technical reports related to nerve agent production, which were later discovered by Allied intelligence. The British also obtained critical documents related to the tabun and sarin pilot plants at Raubkammer from German scientists there and later shipped the disassembled plants to Porton Down.<sup>103</sup>

### Evidence of Gas Use in Germany

Although gas was not used on the battlefields of World War II, HCN gas (trade name Zyklon B), developed by Fritz Haber, was used in Nazi concentration camps first for delousing to control typhus and later for killing prisoners during the Holocaust. (The first-generation cyanide insecticide, known as Zyklon A, contained methyl cyanofomate as the active agent.) Upon exposure to air, the substrates in Zyklon B elaborated vapors of HCN. In Nazi gas chambers, Zyklon B facilities were disguised as shower and decontamination rooms. In 1941 experiments with Zyklon B were performed in Auschwitz I as well as other camps such as Dachau, the longest running concentration camp. Zyklon B was provided by the German companies Degesch and Testa, under license from patent holder IG Farbenindustrie.<sup>103</sup> After the war, two directors of Tesch were tried by a British military court and executed for their part in supplying the chemical.

### German Plans for Gas

Both sides in the war had active plans to use chemical weapons in the event that the other side used them first. The Soviet chemical arsenal was seriously

lacking compared to the stocks available to Germany, and Soviet gas masks had technical defects, which may explain Stalin's no-first-use policy.<sup>109</sup> During the war, the Soviets lacked chemical discipline and adequate protective equipment to instigate a chemical war. During retreats in 1941, many Soviet troops discarded their gas masks and other equipment to lighten their loads. By the end of 1941 fighting had reached a stalemate around Leningrad. Germany planned to breach the Soviet defenses by means of a chemical attack along 20 kilometers near the city, but had insufficient supplies of artillery and gas shells to carry out the maneuver.<sup>109</sup>

In September and December of 1942 General Hermann Ochsner, chief of Germany's chemical warfare division, carried out two attacks with a nonlethal gas to smoke out Soviet guerillas hiding in caves along the Kerch peninsula, a stretch of land forming the opening to the Sea of Azov. The Soviet government claimed the German army was responsible for thousands of deaths and had used chemical weapons in the attack.<sup>109</sup>

Chemical weapons were not used by either side during fierce fighting at Moscow. After defeating German troops at Moscow, Kursk, and Stalingrad, a change from defense to offense in Soviet military strategy renewed an interest in chemical weapons. Soviet intelligence before the Battle of Kursk warned of German use of the chemical weapons. Chief of Staff AM Vasil'ev wrote this directive [translated]:

The general staff possesses information to the effect that the German command has recently heightened the preparedness of its forces for the use of chemical weapons. . . . There are enough risk takers in the German command who, relying on the fact that they could catch us by surprise, might decide on a desperate gamble and use chemical weapons against us.<sup>112(p91)</sup>

### British Plans for Gas

Prime Minister Churchill's position on gas warfare is evident in a four-page memo sent to his chief of staff, General Hastings Ismay:

I urge you to think very seriously over the question of poison gas. . . . It is absurd to consider morality on this topic when everybody used it [gas] in the last war without a word of complaint from the moralists or the Church. On the other hand, in the last war the bombing of open cities was regarded as forbidden. Now everybody does it as a matter of course. It is simply a question of fashion changing as she does between long and short skirts for women. . . . I want

a cold-blooded calculation made as to how it would pay to use poison gas. . . . One really must not be bound within silly conventions of the mind whether they be those that ruled in the last war or those in reverse which rule in this. . . . We could drench the cities of the Ruhr and many other cities in Germany in such a way that most of the population would be requiring constant medical attention. . . . It may be several weeks or even months before I shall ask you to drench Germany with poison gas, and if we do it, let us do it one hundred per cent. In the meantime, I want the matter studied in cold blood by sensible people and not by the particular set of psalm-singing uniformed defeatists which one runs across now here now here now there.<sup>113(p501)</sup>

### US Policy and Plans for Gas

While planning for a traditional, European-style war, the CWS also monitored Japan's use of chemical weapons in China, which increased the US Army's interest in chemical warfare preparation.<sup>114</sup> The CWS, however, was still unprepared to fight a major chemical war on the level of World War I. Increased budgets and personnel helped with war planning, but to actually field chemical weapons and build chemical stockpiles first required industrial mobilization and massive production.

President Roosevelt established a no-first-use policy for chemical weapons early in the war, which was reiterated in an official statement in 1943: "We shall under no circumstances resort to the use of such weapons [chemical] unless they are first used by our enemies."<sup>115(p6)</sup> The policy was backed up by a statement of warning: "Any use of gas by any axis power, therefore, will immediately be followed by the fullest possible retaliation upon munition centers, seaports and other military objectives throughout the whole extent of the territory of such axis country."<sup>115(pp6-7)</sup>

US plans for the final invasion of Japan, code-named Operation Downfall, called for the invasion of Kyushu Island in the fall of 1945, followed by an invasion of the main island of Japan in the spring of 1946. Planners predicted that the attack would lead to a major chemical conflict because Japan had already used chemical weapons against China. The Army Air Force plans called for the use of persistent 100-lb bombs (mustard gas) and nonpersistent 500-lb bombs (60% phosgene, 40% cyanogen chloride). After Germany's surrender in May 1945, the CWS contemplated augmenting their current arsenal of chemical bombs with captured stocks from Germany to address shortages based on required estimates for

a chemical attack of Japan. Mustard gas, phosgene, and tabun were shipped back to the United States to be punched, drained, and used to fill American ordnance rounds.<sup>116</sup> It was subsequently determined that US shells were unsuitable for tabun, but German 10.5-cm projectiles could be used in US howitzers (105-mm) with worn tubes because German shells were slightly wider than US 105-mm shells.<sup>117</sup> In the end, Japan surrendered after nuclear bombs were dropped on Nagasaki and Hiroshima, and chemical warfare in the Pacific was averted.

Although neither Germany nor Japan chose to initiate chemical warfare with the United States, the CWS spent the war training troops; designing chemical, incendiary, smoke, explosive, and flame weapons and protective equipment; and planning for a chemical war. In addition to the M2 4.2-in chemical mortar,<sup>4,28,118</sup> the CWS possessed 75-mm, 105-mm, and 155-mm chemical rounds filled with mustard or lewisite. The US Air Force had 100-lb mustard agent bombs; 500-lb phosgene or cyanogen chloride bombs; and 1,000-lb phosgene, cyanogen chloride, or hydrocyanic acid bombs. In addition, the new M33 spray tank could hold 750 to 1,120 lb of mustard agent or lewisite.

None of these chemical weapons was used on the battlefield during the war,<sup>4,119,120</sup> but the repositioning of chemical weapons in forward areas resulted in one major disaster and several near mishaps. The disaster occurred December 2, 1943, when the SS *John Harvey*, loaded with 2,000 M47A1 mustard agent bombs, was destroyed during a German air raid at Bari Harbor, Italy. The only members of the crew who were aware of the chemical munitions were killed in the raid. As a result of the ship's destruction, mustard agent contaminated the water in the harbor and caused more than 600 casualties, in addition to those killed or injured in the actual attack. The harbor clean-up took 3 weeks and required large quantities of lime as a decontaminant.<sup>121</sup>

### US Lessons Learned

After the war, the phrase "had the United States been prepared for war in 1939, there would not have been a war"<sup>122(p24)</sup> was taken as a self-evident truth. The CWS needed to be a permanent organization that concentrated on training, research and development, and chemical warfare preparedness. This same lesson, from a slightly different angle, was reflected in the words of Under Secretary of War Kenneth C Royall to the chemical warfare specialists: "The better job you do the less likely it is that you will have to put to actual use the products of your work."<sup>123(p41)</sup>

### Demobilization and the Creation of the Chemical Corps

The Army began demobilization activities almost immediately after the president proclaimed the end of hostilities. By early 1946 the CWS was effectively demobilized and its military strength approached pre-war levels. One observer commented, "Gas warfare is obsolete! Yes, like the cavalry and horsedrawn artillery, it is outmoded, archaic, and of historical interest only. This is the atomic age!"<sup>124(p3)</sup>

However, CWS chief Major General Porter advocated for the CWS before an Army board considering postwar organization, resulting in the permanency long sought by the chemical program: a corps designation. The Army finally agreed that the CWS, along with the other technical services, should continue its existence as a distinct entity in the peacetime Army. On August 2, 1946, Public Law 607 changed the name of the CWS to the "Chemical Corps."<sup>125</sup>

After World War II, as Western defense became increasingly based on the threatened use of nuclear weapons, the Chemical Corps' mission expanded to include radiological protection as well as chemical and biological research and development. At the same



**Fig. 2-36.** Decontamination of captured chemical stockpiles. A 250 KC (chemical cylinder) phosgene bomb as it drops into a water tank, where the phosgene is neutralized by hydrolyzation. The bomb has been vented prior to decontamination, and the phosgene vapor can be seen escaping into the air. Schierling, Germany. May 1946. Photograph: Courtesy of Chemical and Biological Defense Command Historical Research and Response Team, Aberdeen Proving Ground, Md.

time, the corps concentrated on producing and fielding nerve agent weapons and the assorted detection and decontamination equipment required.

Major General Alden H Waitt, who replaced Porter in November 1945, assessed the future of chemical warfare in 1946:

The fact that toxic gas was not used in the late war [on the battlefield] does not justify a conclusion that it will not be used in the future. Gas has not been out-moded as a weapon. The Germans developed new gases during World War II. The magnitude of their preparedness for gas warfare is indicated by the fact that they had amassed more than a quarter of a million tons of toxic gas; their failure to use this gas against us is attributable largely to their fear of our retaliatory power. We cannot count upon other nations refraining from the use of gas when it would serve their purpose. There were numerous instances in the late war in which the use of gas might have had far-reaching results. Thus, there is no good reason for assuming that the considerations which prevented the employment of gas in World War II will

prevail in the future.<sup>126</sup>

### Demilitarization of Captured Weapons

At the end of the war, the United States was actively involved in the demilitarization of the thousands of captured munitions from German stockpiles (Figure 2-36). Following the occupation of Germany and Japan, the Allies initiated a sea-dumping and weapons disposal program to eliminate the large stockpiles of captured chemical agents. Ships containing German weapons were sunk in the North Sea as part of Operation Davy Jones' Locker, but not all the German weapons were destroyed. Between 1945 and 1947, some 40,000 of the 250-kg tabun bombs, 21,000 mustard bombs of various sizes, 2,700 nitrogen mustard rockets, and about 750 tabun artillery shells of various sizes were shipped to the United States. In addition to disposing of the enemy stockpiles, the United States dumped the US lewisite stockpile into the sea during Operation Geranium in 1948.<sup>4,127</sup>

## THE 1950s

### Korean War

With the onset of the Korean War in June 1950, the Chemical Corps participated in its first military action. The corps quickly implemented an increased procurement program to supply the Army with defensive equipment and a retaliatory chemical capability. Within a short time, however, the Army's policy on chemical warfare and the lessons learned from the past were disputed, particularly as the military situation in Korea changed. The action in Korea raised the question of whether to initiate chemical warfare to save lives. Many of the Chemical Corps' supporters favored the use of chemical weapons as humane weapons of war, particularly to offset the enemy's superior numbers. One officer stated bluntly that "the use of mustard, lewisite and phosgene in the vast quantities which we are capable of making and distributing offers the only sure way of holding Korea at the present time. We are not playing marbles. We are fighting for our lives. Let's use the best means we have to overwhelm the enemy scientifically and intelligently."<sup>128(p3)</sup>

Although the North Koreans and Chinese alleged that US forces employed chemical weapons on the battlefield, there is no evidence that the Chemical Corps used them, although it did use smoke and flame, as well as riot control agents to quell riots by prisoners of war. In 1968 a Czech general who defected to the United States reported that US prisoners of war were

used for biological tests by the Russians in North Korea. These allegations have yet to be confirmed by the Russians and were vigorously denied by the North Koreans.<sup>129</sup> The United States did not change its policy about no first use of chemical weapons.

At the end of the Korean War, the Chemical Corps was in a much stronger position than it had been at the end of World War II. Although the corps slightly reduced its units and personnel and terminated many of its procurement contracts in the months following the 1953 armistice, Major General Egbert F Bullene, the new chief chemical officer, summed up the feeling of the corps regarding the Korean War and the Cold War in general: "Today, thanks to Joe Stalin, we are back in business."<sup>130(p8)</sup>

### Changes in the Chemical Corps

During the 1950s the concept of chemical warfare continued to change radically. The phrase that one could "push a button" to start a war became popular. The lesson learned from the Korean War—that a limited war, fought without nuclear weapons and possibly against satellite states, not the "real enemy"—determined much of the Army's future planning. The fact that two wars had come and gone without the employment of chemical weapons made it necessary for successive chief chemical officers to continually remind the Army and the country that the capabilities

of the Chemical Corps constituted insurance against the possibility of chemical attack in the future.

Throughout the 1950s the Chemical Corps conducted several extensive studies to improve its organization and training capabilities. A new training center at Fort McClellan, Alabama, opened in 1951 and offered more space and training options. After more than 30 years in Maryland, the Chemical School moved to Fort McClellan early in 1952.<sup>4</sup> The emphasis on individual training for chemical warfare resulted in the elimination of the unit gas officer, who had previously been responsible for chemical training and readiness, in 1954. After the change, troop commanders assumed the responsibility and were expected to include chemical and biological training in all their field exercises and maneuvers.<sup>131</sup>

### Nerve Agent Production and Development

In 1950 the Chemical Corps began constructing its first full-scale sarin production complex based on pilot plant work accomplished at the Army Chemical Center (formerly Edgewood Arsenal). The production of sarin was a 5-step process divided between two sites. For the first two steps of the process, the corps constructed a plant at Muscle Shoals, Alabama, later designated "Site A," or the Muscle Shoals Phosphate Development Works, which was completed in 1953. The last three steps of the process were conducted at a new plant at Rocky Mountain Arsenal, Colorado. In 1951 the corps fully standardized sarin, and by 1953 it was producing the agent. After only 4 years of production, the plants stopped manufacturing because the stockpile requirements for the agent had been met. The plants then went into inactive status with layaway planned. The related munitions filling plants also went into standby status a year later.<sup>4,132</sup>

Part of the reason for the sarin plant's closure was the development of a new nerve agent. While searching for new insecticides, chemists at Imperial Chemicals Limited in the United Kingdom came across compounds extremely toxic to humans. The British shared the discovery with the United States in 1953. The Chemical Corps examined the new compounds and determined that a new series of nerve agents had been discovered that were more persistent and much more toxic than the G-series agents. This new series was designated the "V-series" in 1955 because the agents were venomous in nature. These agents enter the body through the skin, bypassing protective masks. They were 1,000-fold more toxic than sarin when applied to the skin, and 2- to 3-fold more toxic when inhaled. A drop the size of a pinhead on bare skin could cause death within 15 minutes.<sup>4,133</sup>

The Chemical Corps gave top priority to the investigation of these compounds. Of the compounds investigated, VX was selected in 1957 for pilot plant development and dissemination studies. It was standardized in December 1957. The annual report for that year concluded "the reign of mustard gas, which has been called the King of Battle gases since it was first used in July 1917, will probably come to an end."<sup>134(p100)</sup>

The corps initially planned to contract with private industry for a 10-ton-per-day production plant. A later decision put the plant at the inactivated Dana Heavy Water Plant of the Atomic Energy Commission at Newport, Indiana, within the Wabash River Ordnance Works. Construction was delayed because of a patent dispute that resulted in a restraining order. In 1959 Food Machinery and Chemical Company, the low bidder, won the contract and construction was planned for 1960. Shortly after the approval, the Chemical Corps supplemented the contract to provide for a VX weapon-filling plant.<sup>134,135</sup>

The remainder of the 1950s was spent developing new delivery systems and new protective gas masks and improving chemical detection systems, decontaminating methods, and treatments, as well as weaponizing sarin. Although delivery systems for VX nerve agent were initiated during the 1950s, no system was standardized. In addition, many of the sarin delivery systems took longer to develop than planned and some were never standardized.

### Medical Research on Human Volunteers

Concerned with the effects of nerve and other chemical agents on soldiers, the Chemical Corps began extensive studies to determine the dangers of exposure and the proper kinds of treatment. These studies exposed soldiers to low levels of agents to demonstrate the effects of treatment and to investigate the agents' effects on humans.

Before the 1950s the use of humans in testing had been conducted on an ad hoc basis and little documentation survived. During the 1950s a more formal volunteer program was established at the Army Chemical Center that drew on local military installations and utilized a specific consent procedure, ensuring that each volunteer was briefed prior to the experiment. Between 1955 and 1975 over 6,000 soldiers participated in this program and were exposed to approximately 250 different chemicals.<sup>136</sup>

### The Incapacitant Program

During the 1950s the Chemical Corps also became interested in developing chemical weapons that

incapacitated rather than killed its targets. In 1951 the Corps awarded a contract to the New York State Psychiatric Institute to investigate the clinical effects of mescaline and its derivatives. The contractor tested 6 derivatives and the corps tested 35 derivatives. The results of the investigation indicated that mescaline and its derivatives would not be practical as agents because the doses needed to bring about mental confusion were too large.<sup>137</sup>

In 1955 the Chemical Corps formally established a project called "psychochemical agents." The next year, the program was redesignated "K-agents." The objective was to develop a nonlethal but potent incapacitant that could be disseminated from airplanes in all environments. The program was conducted at the Army Chemical Center and examined nonmilitary drugs like lysergic acid (LSD) and tetrahydrocannabinol (related to marijuana). None of these drugs, however, were found to be of military worth.<sup>134,137-139</sup>

### **The Growing Soviet Threat**

While addressing the Communist Party Congress in Moscow in 1956, Soviet Defense Minister Georgi Zhukov warned, "[A]ny new war will be characterized by mass use of air power, various types of

rocket, atomic, thermo-nuclear, chemical and biological weapons."<sup>140(p26)</sup> In 1959 Major General Marshall Stubbs, the new chief chemical officer, assessed the growing Soviet chemical threat, saying:

Soviet chemical weapons are modern and effective and probably include all types of chemical munitions known to the West, in addition to several dissemination devices peculiar to the Russians. Their ground forces are equipped with a variety of protective chemical equipment and they are prepared to participate in large scale gas warfare. They have a complete line of protective clothing which will provide protection in any gas situation and a large variety of decontaminating equipment. . . . I believe that I have given you enough to make you aware that they pose a threat to the free nations of the world.<sup>141(pp 8-9)</sup>

The next year Major General Stubbs talked to various groups around the country about the need for greater urgency in attaining chemical preparedness. Contending that "to both military and civilian populations" the threat of chemical warfare was as great as the threat of nuclear warfare, he reported that the Soviets had about one sixth of their total munitions in chemical weapons.<sup>142</sup>

## **THE 1960s: DECADE OF TURMOIL**

In January 1961 Secretary of Defense Robert S McNamara initiated about 150 projects to provide an appraisal of US military capabilities. Two of these, Project 112 and Project 80, had significant impact on the chemical and biological weapons program. Project 112's objective was to evaluate chemical and biological weapons for use as strategic weapons and for limited war applications. The result of this study was a recommendation to highlight chemical weapons and particularly to increase long-term funding, which was approved for immediate action by the deputy secretary of defense. One of the responses was the creation of Deseret Test Center, Utah, intended for extra-continental chemical and biological agent testing, including trials at sea, and arctic and tropical environmental testing. The new center was jointly staffed by the Army, Navy, and Air Force, with testing scheduled to begin in 1962.

Project 80 resulted in a committee to review the organization of the Army. The project committee eliminated the technical services and distributed their functions to various elements of the new Army organization. McNamara felt that the Chemical Corps' knowledge, experience, and training was not being "infused" into the rest of the Army because the combat

troops were "structurally separated" from the corps, particularly in the areas of research, development, and training.<sup>143</sup>

Colonel John M Palmer, head of the Chemical Corps Training Command, reflected on the problem in 1960:

The quickest way to reduce the effectiveness of a military training program is to train without purpose or sense of urgency. Unfortunately, for 40 years an aimless approach has largely characterized unit chemical warfare training in the U.S. Army. . . . Much of the Army still appears to visualize chemical warfare . . . as an annoying distraction from normal combat training.<sup>144(p28)</sup>

### **The 1962 Army Reorganization**

Based on the problems associated with training combat troops for chemical warfare, the Defense Department ordered a far-reaching realignment of functions in 1962. Most of the technical service headquarters establishments, including that of the Chemical Corps, were discontinued, and their functions merged into three field commands. The training mission of the chief chemical officer was assigned to the Continental Army Command; the development of doctrine was

assigned to the new Combat Development Command; and the logistical function, including all arsenals, laboratories, and proving grounds, was assigned to the new Army Materiel Command.<sup>145</sup>

The effects of the reorganization were quickly felt. Within 2 years, the chemical warfare training program had significantly improved. One junior officer, A Harrigan, described the changes:

We have set up special 40-hour or 80-hour schools so that we can have a trained CBR [chemical-biological-radiological] officer and noncommissioned officer in every company-sized unit. We have assigned a chemical officer down to brigade, and a chemical operations sergeant down to battalion. We set aside a certain number of hours annually for classroom instruction for the troops. We set up special blocks of instruction for surveying and monitoring teams. We list CBR defense as a subject integrated into our training schedules, and we may even throw tear gas grenades or other agents at troops in the field.<sup>145(p16)</sup>

Harrigan, however, concluded that more realistic field training was still required to prepare soldiers for the modern battlefield with nuclear weapons and nerve agents.<sup>145</sup>

### Beginning of the Vietnam War

The growing guerrilla war in South Vietnam made the Army again reexamine its training program, chemical warfare readiness, and no-first-use policy. In 1963 one observer stated that, "after years of almost total lack of interest, the U.S. has taken up guerrilla warfare training as though it were something new under the sun."<sup>146(p12)</sup> As part of that sudden interest, the role of chemical weapons again came under intense scrutiny and debate. That same year, Harrigan wrote in the *Armed Forces Chemical Journal*, "the best way for the U.S. to achieve its military aims in Southeast Asia would be to rely on chemical warfare."<sup>146(p12)</sup> He described how soldiers could "sanitize" a large area with gases and sprays that killed everything from vegetation to humans.<sup>146</sup>

In 1966 a retired US Army general suggested that mustard gas be used to clear Vietnamese tunnels. He thought the use of low-lethality chemicals would save both American and Vietnamese lives by rendering the tunnels useless.<sup>147</sup> Other observers and authors also recommended revising the no-first-use policy. Public opinion and national policy opposing the use of toxic chemicals was apparently the deciding factor against their employment. The Army did, however, utilize defoliants and nonlethal riot control agents in large quantities. The negative worldwide response required

the Army to make clear the differences between lethal and nonlethal chemicals.

The expansion of hostilities in Vietnam caused a gradual rise in the level of development and procurement of chemical-warfare-related items. By virtue of their training and specialized equipment, Chemical Corps personnel were able to make a number of contributions, primarily in the areas of riot control and flame weapons.

### Yemen Civil War

While the United States was becoming involved in the Vietnam War, a small war in the Middle East brought the subject of chemical warfare back from the hypothetical. In September 1962, just after the death of Imam Ahmad, a military coup of Yemeni dissidents overthrew the royalist monarchy and declared a republic. The new imam escaped assassination and retreated with his royalist forces into the mountains of northern Yemen, initiating a counter revolt against the republican forces. Egyptian President Gamal Abdul Nasser recognized the new republic and sent military forces to help defeat the royalist troops, who were supported by the kingdoms of Saudi Arabia, Iran, and later Jordan, straining inter-Arab tensions, mainly between Saudi Arabia and Egypt.<sup>148,149</sup>

Egyptian efforts to defeat the royalist forces and destroy their civilian support bases proved particularly difficult in the mountainous terrain of northern Yemen. Frustrated by the successful royalist guerrilla tactics, Egypt employed chemical weapons they had developed in the 1950s and obtained from the Soviet Union; defensive equipment was also obtained from the Soviets.<sup>150</sup> Egypt was the first Arab state to use chemical weapons. Despite having signed the 1925 Geneva Convention, which outlawed the use of chemical weapons, Egypt employed chloroacetophenone tear gas, mustard blistering gas, phosgene, and nerve agents repeatedly from 1963 to 1967.<sup>151</sup>

Some of these chemical weapons were made in military plant no. 801 in Abu-Za'abal, near Cairo. Egypt received mustard-gas-filled KHAB-200 R5 aerial bombs and phosgene-filled AOKh-25 aerial bombs from the Soviet air force and secured numerous mustard-filled shells from British stocks abandoned in Egypt after World War II.<sup>149,152,153</sup> Some accounts attributed the chemical weapons to German scientists, usually described as Nazis, who had been brought to Egypt by President Nasser. Several sources reported that the Soviet Union, through its friendship with Egypt, used Yemen as a testing ground for its chemical research program. Other reports mentioned Communist China as the supplier.<sup>154-161</sup>

Egypt denied ever using chemical warfare during its support of the new republican forces, but early accounts and evidence of chemical warfare came from journalists in the area. On June 8, 1963, Soviet-made Egyptian air force airplanes dropped chloroacetophenone tear gas bombs on numerous royalist villages south of Sadah, near Saudi Arabia. Egypt allegedly used the bombs to terrorize or kill not only the village inhabitants but also the royalists hiding in caves and tunnels. An alleged attack took place in July 1963 against the village of Al Kawma and killed seven civilians. The United Nations (UN) investigated the allegation by sending an observation team to Yemen, but its report found no evidence of a chemical attack.<sup>154</sup>

Newspaper articles described additional chemical attacks taking place from 1963 to 1967, although most disagreed on the dates, locations, and effects of the attacks. In January 1965 Egypt used a combination of chloroacetophenone and mustard gas for the first time on villagers in the Mount Urush region. A concoction of phosgene and mustard was dropped on citizens in the Sherazeih region, northeast of Sana, between March and July. The United States, involved in its own controversy concerning the use of riot control agents in Vietnam, took little notice of the reports.

In January 1967 an attack occurred on the Yemeni village of Kitaf. During this air raid, bombs were dropped upwind of the town and produced a gray-green cloud that drifted over the village. According to newspaper accounts,<sup>165-159</sup> 95% of the population up to 2 km downwind of the impact site died within 10 to 50 minutes of the attack. All the animals in the area also died. The estimated total human casualties numbered more than 200. Another reported attack took place on the town of Gahar in May 1967, killing 75 inhabitants. Additional attacks occurred that same month on the villages of Gabas, Hofal, Gadr, and Gadafa, killing over 243 occupants. In addition, two villages in Saudi Arabia near the Yemen border were bombed with chemical weapons.

Shortly after these attacks, the International Red Cross examined victims, soil samples, and bomb fragments and officially declared that chemical weapons, identified as mustard agent and possibly nerve agents, had been used in Yemen. Much like the progression of chemicals used during World War I, the Egyptians allegedly started with tear gases, which were meant to terrorize more than kill, before progressing to mustard agents, which caused more serious casualties, and finally to nerve agents, which were meant to kill large numbers quickly. This was the first use of nerve agents in combat. The combination of the use of nerve agents by the Egyptians in early 1967 and the outbreak of war between Egypt and Israel during the Six-Day War in

June finally attracted world attention to the events in Yemen. The Saudi government protested the Egyptian use of chemical weapons to the UN. U Thant, secretary general of the UN, sought to confirm the use of chemical weapons with the Egyptians, but they denied it. The UN apparently took little further notice of the situation. At the height of the conflict, Egypt had 75,000 troops in Yemen, but the Six-Day War with Israel and subsequent defeat in June 1967 forced it to withdraw troops from Yemen and negotiate a peace deal. The Yemen civil war officially ended with the Compromise of 1970, a political agreement between the republican and royalist factions. A republican government was formed in Yemen, incorporating members from the royalist faction but not the royal family.<sup>154-161</sup>

Much of what the US Army learned from the Yemen civil war was negative. Reports of possible chemical use in certain areas of the world, particularly those areas inaccessible to official and technical observers, were difficult to confirm or even condemn without accurate and verifiable information. News reports alone proved informative but unreliable. Even samples from the alleged attacks apparently did not lead to further political or military action. Most importantly, with the world distracted by the Arab-Israeli Six-Day War and events in Vietnam, politics discouraged a universal condemnation and follow-up response. In effect, the world powers let the event pass much as they had when Italy used chemical warfare against Ethiopia in the 1930s.

### **Six-Day War**

The 1967 Arab-Israeli Six-Day War came very close to being the first major war in which both combatants openly used nerve agents and biological warfare. On June 5, 1967, fearing a pending attack from its Arab neighbors, Israel launched a preemptive strike against Jordan, Egypt, and Syria. They invaded the Sinai Peninsula, Jerusalem's Old City, Jordan's West Bank, the Gaza Strip, and the Golan Heights.

Reports soon appeared alleging that the Egyptians had stored artillery rounds filled with nerve agents in the Sinai Peninsula for use during the war. Israelis, reflecting on Egypt's possible testing of the weapons in Yemen earlier in the year, suddenly realized that their troops and cities were vulnerable to attack. The fact that chemical weapons were not used during the war was possibly due to Israel's preemptive action or to the newspaper reports of the Yemen civil war. Israel placed orders for gas masks with Western countries. However, a UN-sponsored ceasefire ended the fighting on June 10, 1967, and the potential chemical war did not occur.<sup>73,155,156,161</sup>

## Development of Incapacitating Chemical Agents

While concern over the use of chemical agents grew during the 1960s, the United States continued its chemical agent production program. Although the Newport VX production plant was completed in 1961 and began producing agent, it operated for only 7 years before being placed on standby.<sup>4</sup>

The only incapacitating agent (excluding riot control agents) standardized by the Army completed development in 1962. Designated "BZ," 3-quinuclidinyl benzilate was a solid but was disseminated as an aerosol. The major problem with using the agent for military purposes was its prolonged time of onset of symptoms, estimated at 2 to 3 hours, before the enemy became confused and vulnerable. A second problem was the visible cloud of smoke produced during dissemination, which limited the element of surprise.<sup>143</sup>

## Public Hostility Toward Chemical Weapons

The growing protests over the US Army's role in Vietnam, the use of defoliants, and the use of riot control agents both in Southeast Asia and inside the country, as well as heightened concern for the environment all gradually increased public hostility toward chemical weapons. Three events particularly galvanized public attention: the sheep-kill incident at Dugway Proving Ground, Operation Cut Holes and Sink 'Em (CHASE), and an accident with sarin at Okinawa.

### *Dugway Incident*

The first event, according to Dugway Proving Ground's incident log, started with a telephone call on Sunday, March 17, 1968:

At approximately 1230 hours, Dr. Bode, University of Utah, Director of Ecological and Epidemiological contract with Dugway Proving Ground (DPG), called Dr. Keith Smart, Chief, Ecology and Epidemiology Branch, DPG at his home in Salt Lake City and informed him that Mr. Alvin Hatch, general manager for the Anschute Land and Livestock Company had called to report that they had 3,000 sheep dead in the Skull Valley area.<sup>162(pA-1)</sup>

Skull Valley was adjacent to Dugway, one of the Army's open-air testing sites for chemical weapons. Although the findings were not definitive, the general opinion was that nerve agents had somehow drifted out of the test area during aerial spraying and had killed the nearby sheep. Whether the Army was guilty or not, the result was bad publicity and, even more

damaging, congressional outrage.

### *Operation CHASE*

The second event involved a series of sea dumps of surplus chemical warfare agents, primarily mustard agent and some nerve agent, and a problem weapon system, the relatively new M55 rocket system. Although the M55 had been standardized only 7 years before, the thin aluminum head design proved faulty for long-term storage. The problem of leaking rockets started in 1966, and a year later the Army began disposing of the rockets, sealed in concrete vaults in the hulls of ships that were then sunk in ocean-disposal sites. Operation CHASE, an ongoing program for disposing of conventional ammunition, began accepting chemical weapons in 1967. That year, CHASE 8 disposed of mustard agent in ton containers and M55 sarin rockets. In June 1968 CHASE 11 disposed of sarin and VX in ton containers, along with additional M55 sarin and VX rockets. In August 1968 CHASE 12 disposed of mustard agent in ton containers.<sup>4</sup>

These dumps created significant environmental concerns throughout the country, including fears of an accident during transportation of the weapons by train from storage depots to loading docks, and environmental and commercial concern about the sunken agents' effects on marine life.

### *Accident at Okinawa*

On July 8, 1969, the Army announced that 23 US soldiers and 1 US civilian had been exposed to sarin on Okinawa. The soldiers were cleaning sarin-filled bombs preparatory to repainting them when the accident occurred.<sup>4</sup> Although none of the individuals died, the public announcement created two controversies. First, up until that time, the Army had kept secret the forward positioning of chemical weapons on Okinawa, and this acknowledgment created international concerns. Second, the accident pointed out the dangers of storing chemical weapons. With chemical weapons known to be stored at sites in the continental United States near cities and residential areas, the fear of an accident escalated. On July 22, 1969, in response to these concerns, the Defense Department announced that it would accelerate the previously planned removal of the chemical agents from Okinawa.<sup>163</sup>

## Changes to the Chemical Warfare Program

In April 1969 the secretary of defense tried to explain the US chemical warfare policy to both the general public and to Congress, stating:

It is the policy of the United States to develop and maintain a defensive chemical-biological (CB) capability so that U.S. military forces could operate for some period of time in a toxic environment if necessary; to develop and maintain a limited offensive capability in order to deter all use of CB weapons by the threat of retaliation in kind; and to continue a program of research and development in this area to minimize the possibility of technological surprise.<sup>164(p193)</sup>

Despite this statement, the UN released a report on chemical weapons that July condemning the production and stockpiling of weapons of mass destruction. Six days later, the United States acknowledged the Okinawa accident.<sup>4</sup> On July 11, 1969, Congress revealed that the Army was conducting open-air testing with nerve agents at Edgewood Arsenal (the name of the Army Chemical Center had reverted in 1963) and at Fort McClellan during training events. Shortly after the disclosure, more than 100 people protested at the gates of Edgewood Arsenal. Three days later the Army announced suspension of open-air testing at the two sites and promised to conduct a safety review of all such testing. However, the public was again displeased when the Army revealed that it had also conducted nerve agent testing in Hawaii between 1966 and 1967, something it had previously denied.<sup>4</sup>

In October the secretary of the Army announced that the safety review had been completed, with the following conclusion: "The lethal testing program at Edgewood Arsenal during the past two decades has compiled an enviable record for safety. The testing procedures that have been evolved are clearly effective in minimizing danger to base personnel and

civilians in adjacent areas."<sup>165(p16)</sup> The committee's only major concern was the movement of chemical agents by truck on public roads. It recommended resumption of lethal agent open-air testing at Edgewood.<sup>165</sup> Before testing resumed, however, Congress passed Public Law 91-121 in November, imposing controls on the storage, testing, and disposal of agents outside the United States and the testing and transportation of chemical agents within the country. Further open-air testing of lethal chemical agents was effectively banned.<sup>4</sup>

In November 1969 President Richard Nixon took action against chemical warfare, effectively stopping the production of chemical weapons in the United States.<sup>166</sup> First, he reaffirmed the no-first-use policy for chemical weapons, saying, "I hereby reaffirm that the United States will never be the first country to use chemical weapons to kill. And I have also extended this renunciation to chemical weapons that incapacitate."<sup>166(p5)</sup> Second, he decided to resubmit the 1925 Geneva Protocol to the US Senate for ratification. The Senate had refused to ratify the treaty when it was first signed, and President Harry S Truman had withdrawn the treaty from the Senate in 1947. Nixon explained his future hopes: "Mankind already carries in its own hands too many of the seeds of its own destruction. By the examples that we set today, we hope to contribute to an atmosphere of peace and understanding between all nations."<sup>166(p4)</sup> (The US Senate did not grant Nixon's request till 1974, and President Ford officially signed the protocol on January 22, 1975, after exempting riot control agents and herbicides from the agreement.<sup>4</sup>)

### THE 1970s: THE NEAR END OF THE CHEMICAL CORPS

The events of 1969 had a severe impact on the future of the US Army chemical warfare program. In February 1970 President Nixon added toxins to the list of banned weapons and ordered all existing stocks of toxin agents destroyed. About a month later, the Army revealed it had conducted chemical testing in Alaska but reported that the testing had stopped. The Army also announced that the chemical weapons on Okinawa would be moved to Umatilla Army Depot in Oregon, which triggered a series of lawsuits that attracted the congressional concern. The next year, Public Law 91-672 prohibited the Army from moving the weapons from Okinawa to anywhere on the US mainland. Finally, Operation Red Hat moved the stockpile on Okinawa to Johnston Atoll, a small US island in the South Pacific, for long-term storage and eventual demilitarization.<sup>167</sup>

Because of heightened environmental concerns in

the 1970s, demilitarization was not an easy project. One last sea dump took place in 1970 when, despite much negative press, CHASE 10 disposed of more M55 sarin rockets. (CHASE 10 had originally been scheduled to start earlier; although now out of numerical order, the designation was unchanged.) Two years later Public Law 92-532 prohibited the sea dumping of chemical munitions.<sup>167</sup>

A senior Department of Defense official reflected on the impact the restrictions had during the 1970s: "During most of the 1970s, the United States allowed its chemical retaliatory capability to decline, did little to improve chemical protection, and neglected relevant training and doctrine. The United States has not produced lethal or incapacitating chemical agents, or filled munitions since 1969."<sup>167(p3)</sup> The Army made plans to abolish the Chemical Corps entirely. In 1973, with the Paris Peace Accords and the end of the draft,

the Army recommended reducing the Chemical Corps in size and eventually merging it with the Ordnance Corps. As the first step, the Army disestablished the chemical school at Fort McClellan and combined it with the ordnance school at Aberdeen Proving Ground. Congress, however, blocked the complete disestablishment of the corps.<sup>168-171</sup> Still, one observer noted: "As an additional ordnance career field, the chemical specialty almost withered and died at Aberdeen."<sup>171(p15)</sup>

### Yom Kippur War

The Arab-Israeli Yom Kippur War lasted only from October 6 to October 24, 1973, but it brought chemical warfare preparedness back to public attention and its ramifications for the US chemical program lasted much longer. Egypt had several years to stockpile and increase its arsenal to plan an attack on Israel involving chemical weapons. Syria, Egypt's ally in the war, began stockpiling a chemical arsenal, receiving sarin from Egypt in 1972. The Egyptian and Syrian attack against Israel on Yom Kippur and the successful Israeli counterattacks ended with a ceasefire. Both sides took enormous losses in personnel and equipment. However, chemical weapons were not employed by either side.

Following the war, the Israelis analyzed the Soviet-made equipment they captured from the Egyptians and Syrians. They discovered portable chemical-proof shelters, decontamination equipment for planes and tanks, and air-filtration systems that removed toxic chemicals on most Soviet vehicles. They also found a Soviet PKhR-MV chemical agent detector kit for medical and veterinary services. The kit, which consisted of a hand pump, detector tubes, reagents in ampules, dry reagents, test tubes, and accessories, was designed to detect nerve, blister, and blood agents. US specialists determined that it could detect low concentrations of nerve agents, mustard agent, cyanide, lewisite, and heavy metals in aqueous solutions. It could also detect the same agents, plus cyanogen chloride and phosgene, in the atmosphere. However, procedures for using the kit were extremely difficult to carry out while wearing a protective suit. In addition, the glass ampules were fragile and broke easily.<sup>172</sup>

Overall, the experts reported finding sophisticated chemical defense materiel and a "superior quantitative capability for waging a chemical war."<sup>173(p3-4)</sup> The indications were that the Soviets were ready for, and might actually be planning to instigate, extensive chemical warfare in a future war. Soviet division commanders were thought to already have the authority to initiate chemical warfare.<sup>173-176</sup>

### Restoring the Chemical Corps

The decline of the US Army Chemical Corps, combined with the discovery of sophisticated Soviet chemical defense materiel and the Soviet's capability for waging chemical war, made corrective action necessary. The Army concluded the following:

To offset this, U.S. chemical/biological (CB) defense materiel must not only provide a protective system equivalent to or better than that of any potential enemy but the physiological and logistics burdens must be such as to permit long-term use. To cope with the hazards of any potential CB-threat environment requires the development of an integrated CB defense system. This system must contain items for individual protection, collective protection, decontamination, warning and detection, and safe devices and concepts to achieve realistic training. An effective technological base is needed from which such materiel, responsive to user needs, can be quickly developed.<sup>173(p3-4)</sup>

In 1976 the secretary of the Army reversed the decision to abolish the Chemical Corps, citing the heightened awareness of the Soviet Union's capability to wage chemical warfare as the primary reason. In 1977 the United States started a new effort to reach an agreement with the Soviets on a verifiable ban on chemical weapons, but the effort was unsuccessful. The chemical school was reestablished at Fort McClellan in 1979 partly as a result of this failure.<sup>167,177-181</sup>

### Growing Danger of Chemical Warfare

Starting in about 1975, reports of the use of chemicals and toxin agents in various skirmishes and wars in Southeast Asia and Afghanistan began to attract US attention. Interviews with villagers in Laos suggested that Vietnamese and Soviet forces might have used chemical and possibly toxic weapons against the Hmong. Starting in 1978, similar reports from Kampuchea claimed that the Vietnamese and their allies had killed over 980 villagers using chemical weapons. Reports began circulating that Soviet troops were using chemical weapons against Afghan soldiers even before the Soviet invasion of Afghanistan began in December 1979.

Although they had signed the Geneva Protocol in 1928, the Soviets argued that their use of chemical weapons was legitimate because Laos, Kampuchea, and Afghanistan were not signatories. The Soviet Union, Laos, and Afghanistan signed the Biological Weapons Convention in 1975, but the allegations of toxin use were never acknowledged by the Soviets or their allies. When

the Soviets signed the Biological Weapons Convention, they added, "the Soviet Union does not possess any bacteriological agents and toxins, weapons, equipment or means of delivery."<sup>182(p6)</sup> Other intelligence sources thought that the Soviets considered most toxins to be chemical agents, and therefore not subject to the Bio-

logical Weapons Convention. If toxins were considered chemical agents, then the Soviets would be permitted under the Geneva Protocol to use them in retaliation or against nonsignatories.<sup>183</sup> Their use of chemical weapons was taken as an indication that the Soviets were continuing an active chemical program.

## THE 1980s: RETURN OF THE CHEMICAL CORPS

### The Haig Report

Despite denials by the governments involved, the United States publicized charges that chemical warfare had been used in Southeast Asia and Afghanistan in 1980. Problems with the collection of samples and the remoteness of the sites, however, prevented definitive evidence from being obtained. Furthermore, the later identification, discussion, and media debate over the origin of possible trichothecene mycotoxins in Southeast Asia also distracted public interest from the alleged use of conventional chemical munitions.

In 1982 Secretary of State Alexander M Haig, Jr, presented a report titled "Chemical Warfare in Southeast Asia and Afghanistan" to the US Congress. After describing the evidence, he concluded:

Taken together, this evidence has led the U.S. Government to conclude that Laos and Vietnamese forces, operating under Soviet supervision, have, since 1975, employed lethal chemical and toxin weapons in Laos; that Vietnamese forces have, since 1978, used lethal chemical and toxin agents in Kampuchea; and that Soviet forces have used a variety of lethal chemical warfare agents, including nerve gases, in Afghanistan since the Soviet invasion of that country in 1979.<sup>182(p6)</sup>

Based on this evidence, senior Defense Department personnel concluded that the Soviet Union "possesses a decisive military advantage because of its chemical capabilities."<sup>167(p3)</sup> The Haig report, however, was not able to galvanize world opinion. As in the Yemen civil war, the United States was unable to prove that chemical agents and toxins had been used in Southeast Asia and Afghanistan. Instead, the accusation became a political debate between the United States and the Soviet Union during President Ronald Reagan's administration.

### Afghanistan and Iran-Iraq Wars

#### *Afghanistan War*

The US Army monitored the war in Afghanistan

throughout the 1980s, often thinking of it as "the Soviet's Vietnam." The lessons learned from this war about chemical warfare provided extensive support to the US chemical defense program. The Soviets tended to use chemical weapons much like the Italians did in Ethiopia and like the US Army had used nonlethal agents in Vietnam. One military writer summed up the general lesson learned:

The use of chemical weapons by Soviet forces in Afghanistan is also significant. The use of these weapons in Afghanistan confirms, not surprisingly, that the Soviets find them put to their best use against unprotected subjects incapable of retaliation. Afghanistan is proof positive that the Soviets do not consider these devices as special weapons. Considerations of utility and not morality will govern Soviet use of them in a future conflict.<sup>184(p27)</sup>

Despite the use of chemical weapons, the Soviets were unable to "win" the war and, in December 1988, met with rebel forces to discuss a withdrawal of Soviet troops from Afghanistan. In January 1989 the Soviets announced the final withdrawal, which was completed a month later.<sup>185</sup>

#### *Iran-Iraq War*

The United States continued to propose chemical treaties with the Soviet Union, its primary chemical warfare rival. However, the Iran-Iraq War began changing this situation. On September 22, 1980, Iraq launched an invasion against neighboring Iran. The Iraqi army, trained and influenced by Soviet advisors, had organic chemical warfare units and a wide variety of delivery systems. Neither side achieved dominance and the war quickly became a stalemate.

To stop the human-wave-attack tactics of the Iranians, the Iraqis employed their home-produced chemical agents as a defensive measure against the much-less-prepared Iranian infantry. The first reported use of chemical weapons occurred in November 1980. Throughout the next several years, additional reports of chemical attacks circulated, and by November 1983, Iran began complaining to the UN that Iraq was using chemical weapons against its troops.<sup>186-189</sup>

After Iran sent chemical casualties to several Western nations for treatment, the UN dispatched a team of specialists to the area in 1984, and again in 1986 and 1987, to verify the claims. The conclusion from all three trips was the same: Iraq was using chemical weapons against Iranian troops. In addition, the second mission stressed that Iraq's use of chemical weapons appeared to be increasing. The reports indicated that mustard and tabun were the primary agents used, and that they were generally delivered in bombs dropped by airplane. The third mission (the only one allowed to enter Iraq) also reported the use of artillery shells and chemical rockets and the use of chemical weapons against civilian personnel.<sup>190-192</sup>

In the letter of transmittal to the UN after the conclusion of the third mission, the investigators pointed out the dangers of this chemical warfare:

It is vital to realize that the continued use of chemical weapons in the present conflict increases the risk of their use in future conflicts. In view of this, and as individuals who witnessed first hand the terrible effects of chemical weapons, we again make a special plea to you to try to do everything in your power to stop the use of such weapons in the Iran-Iraq conflict and thus ensure that they are not used in future conflicts. . . . In our view, only concerted efforts at the political level can be effective in ensuring that all the signatories of the Geneva Protocol of 1925 abide by their obligations. Otherwise, if the Protocol is irreparably weakened after 60 years of general international respect, this may lead, in the future, to the world facing the specter of the threat of biological weapons.<sup>190</sup>

Another analyst echoed these sentiments, saying, "In a sense, a taboo has been broken, thus making it easier for future combatants to find justification for chemical warfare, this aspect of the Iran-Iraq war should cause Western military planners the gravest concern."<sup>193(pp51-52)</sup>

The Iran-Iraq War failed to reach a military conclusion despite Iraq's use of chemical weapons. Roughly 5% of the Iranian casualties were caused by chemical weapons. Although Iranian use of chemical weapons was rumored, less attention was devoted to verifying those reports. In August 1988 Iraq finally accepted a UN ceasefire plan.<sup>185</sup>

## THE 1990s: A NEW AGE OF CHEMICAL WARFARE AND TERRORISM

### Persian Gulf War

Despite the ongoing political efforts to abolish

### Additional Reports of Chemical Warfare

The end of the Iran-Iraq War did not prevent new chemical warfare reports from circulating. Within a month of the war's end, the Kurds, a minority group in Iraq seeking autonomy, accused Iraq of using chemical weapons against them. Shortly before, rumors circulated that Libya had used chemical weapons obtained from Iran during an invasion of Chad. The United States rushed 2,000 gas masks to Chad in response. There were also reports of the Cuban-backed government of Angola using nerve agents against rebel forces.<sup>194-197</sup>

### Chemical Training

In addition to establishing a retaliatory capability, the US Army significantly improved its chemical training capability by constructing a new facility at the chemical school and conducting more realistic field training. In 1987 the Chemical Decontamination Training Facility started live chemical agent training in a controlled environment. Major General Gerald G Watson, the school's commandant, was "the first American to wear the battledress overgarment in a toxic chemical environment"<sup>198(p15)</sup> when he entered the facility on February 19, 1987. Realistic field training, such as Operation Solid Shield 87<sup>199</sup> (see Chapter 3, History of the Medical Management of Chemical Casualties) was conducted, resulting in changes in Army policy.

### Soviet-US Agreement

The increase in the US retaliatory and defensive capability for chemical warfare, along with internal changes in the Soviet Union, helped convince the Soviets to look closely at a new chemical weapons treaty. In 1987, after admitting possession of chemical agents for the first time, the Soviet Union announced it was halting chemical weapons production. In September 1989 the Memorandum of Understanding (MOU) Between the Government of the United States and the Government of the USSR Regarding a Bilateral Verification Experiment and Data Exchange Related to Prohibition of Chemical Weapons, otherwise known as the Wyoming MOU, started the talks between the two countries.<sup>4</sup> The US demilitarization program continued, despite problems (see Chapter 4).

chemical warfare (see Chapter 4), world events again brought chemical weapons to daily news reports. On August 2, 1990, Saddam Hussein sent Iraqi troops into

Kuwait, allegedly in support of Kuwaiti revolutionaries who had overthrown the emirate. On August 8 Iraq announced that Kuwait had been annexed and was now a part of its country. In response, President George Bush ordered US forces to be sent to Saudi Arabia at the request of the Saudi government as part of what became Operation Desert Shield, the buildup phase of the Persian Gulf War.

The US response to Iraq's invasion put the Army's chemical warfare experience, training, production program, and lessons learned in the limelight. Not since World War I had US troops been sent to face an enemy that had used chemical weapons extensively within the last few years and had publicly announced its intentions to use them against the United States. William H Webster, director of the Central Intelligence Agency, estimated that Iraq had 1,000 tons of chemical weapons loaded in bombs, artillery rounds, rockets, and missiles. Much of Iraq's biological weapons program remained unknown until after the war.<sup>200-202</sup>

By 1991 Iraq's production facility at al-Hakam had produced about 125,000 gallons of agents that cause botulism, anthrax, and other illnesses. After stating for years that the plant was used to produce animal feed, in 1995 the Iraqis admitted it was a biological warfare production facility. In addition to producing biological warfare agents, the Iraqis also conducted live-agent tests on animals. The Iraqis later admitted they had prepared about 200 biological missiles and bombs.<sup>203-206</sup>

To prepare for the military phase of the Persian Gulf War, the United States had to consider all the chemical and biological threats. Troops were given the Mark I (Meridian Medical Technologies Inc, Bristol, Tenn) nerve agent antidote kit, consisting of an atropine autoinjector and a pralidoxime chloride autoinjector to treat nerve agent poisoning. Atropine blocks the effects of nerve agent poisoning on the muscles, and pralidoxime chloride reactivates acetylcholinesterase. Pyridostigmine bromide tablets were also provided as a nerve agent pretreatment.<sup>207</sup> US troops moving into the area were given vaccines for anthrax and botulinum toxin.<sup>208</sup> All military units were fully equipped with the latest chemical and biological defensive equipment, and training was continuous.

The actual attack on Iraq on January 16, 1991, as part of the UN-mandated effort to free Kuwait, was designated Operation Desert Storm by the United States. The attack escalated fears of a new chemical war to levels not seen since World War I. The initial air attack concentrated on Iraqi chemical production facilities, bunkers, and lines of supply. While the air attacks were ongoing, daily news accounts addressed the potential for chemical and biological warfare. On January 28 Saddam Hussein told Peter Arnett of CNN News that Iraqi Scud

missiles, which were already hitting Israel and Saudi Arabia, could be armed with chemical, biological, or nuclear munitions. While visiting the United Kingdom, Vice President Dan Quayle reportedly told the prime minister that the United States had not ruled out the use of chemical or nuclear weapons.<sup>209</sup> Likewise, the United States reportedly threatened to target Hussein personally if he used chemical weapons against UN coalition forces.<sup>209,210</sup> In turn, Iraq reportedly threatened to use chemical weapons against coalition forces if they continued the high-level bombings against Iraqi troops.<sup>209</sup>

When coalition forces began the ground war on February 23, 1991, chemical and biological defense specialists anticipated the worst. Chemical alarms frequently went off across the battlefield, but all were dismissed as false alarms. On February 27 coalition forces liberated Kuwait City and finished destroying the Iraqi divisions originally in Kuwait. No known chemical or biological attacks were made by the Iraqis.

A number of reasons surfaced after the war for why the Iraqis had not initiated large-scale chemical warfare. Vice Admiral Stanley Arthur, commander of US naval forces, thought that because the wind suddenly changed at the start of the land battle, the Iraqis realized that chemical weapons could harm their own troops. Some thought the speed of the campaign was the critical reason. Others reported that the combination of coalition bombing and the resulting Iraqi logistical chaos prevented the chemical weapons from ever reaching the front lines. General H Norman Schwarzkopf, commander of coalition forces, mentioned that Iraq might have feared nuclear retaliation.<sup>202,209,211</sup>

After the war, allegations of chemical exposures began to surface. The Department of Defense initially denied that any chemical exposures had taken place, but veterans of the war claimed the opposite and their ailments collectively became known as "Gulf War" syndrome. By 1996 newspapers reported that almost 60,000 veterans of the Persian Gulf War claimed some sort of medical problem directly related to their war activities. Extensive research by the Department of Defense failed to find any single cause for the problems.<sup>212,213</sup>

One controversial example of possible exposure occurred on March 4, 1991, at the Kamisiyah arsenal, northwest of Basra, involving the US Army 37th Engineer Battalion. After capturing the site, the engineers blew up the Iraqi storage bunkers. According to newspaper accounts, engineers claimed that their chemical agent detectors went off during the explosions. Later the same year, a UN inspection team reportedly found the remains of chemical rockets and shells in one of the bunkers in addition to traces of sarin and mustard agent. In 1996 the Department of Defense acknowledged that one of the bunkers probably contained

sarin- and mustard-agent-filled munitions, and that as many as 20,000 US soldiers may have been exposed to chemical agents as a result.<sup>214</sup> Afterward a Pentagon spokesperson, commenting on the continuing research into the possible exposure, said, "Our understanding of this episode is still partial."<sup>213(pA-10)</sup>

### **Additional Allegations of Chemical Warfare**

Shortly after the fighting between Iraq and coalition forces ended, reports circulated that Hussein was using chemical agents against rebellious Kurds and Shiite Muslims. The United States intercepted a message ordering the use of chemical weapons against the cities of Najaf and Karbala. President Bush's response was that such use of chemical weapons would result in air strikes against the Iraqi military organization

using the chemicals. Thus, despite the end of fighting, Iraqi chemical weapons continued to be a problem for the world.<sup>215,216</sup>

US intelligence sources also detected increased chemical development activity in Libya. A Libyan chemical weapons plant at Rabta had produced about 100 tons of agent by 1990, when Libya claimed that the plant was destroyed by a fire. New disclosures surfaced in 1996 that Libya was constructing a second chemical production plant at Tarhunah. US intelligence sources claimed that this would be the largest underground chemical weapons plant in the world, covering roughly 6 square miles and situated in a hollowed-out mountain. Because Scud missiles have a range of 180 to 300 miles, Libya's neighbors were considerably threatened. Libya strongly denied the US accusation.<sup>217,218</sup>

## **PREVENTING CHEMICAL WARFARE AND TERRORISM IN THE 21ST CENTURY**

Despite the signing of long-sought Chemical Weapons Convention by the United States, Russia, and other countries, and the start of large-scale chemical weapons destruction programs in the 1990s (see Chapter 4), the beginning of the 21st century saw a sudden and dramatic change in the interest in chemical warfare. The events of 2001 made US post offices, government buildings, hospitals, and media headquarters the front lines in a new war on terrorism.

### **Operation Enduring Freedom**

The new war began on September 11, 2001, when four commercial planes were hijacked. Two crashed into the World Trade Center, one into the Pentagon, and one crashed in rural Pennsylvania before reaching its apparent target in Washington, DC. Nearly 4,000 people died in the destruction and aftermath, including many first responders. Almost immediately Al Qaeda, under the control of Osama bin Laden, was identified as the perpetrator. Although the terrorists were protected by the ruling party in Afghanistan, the Taliban, the United States began a military counterstrike.

In October 2001 the United States launched massive air attacks against Afghanistan. Special Forces troops entered the war to assist the Northern Alliance in their ongoing rebellion against the Taliban. In November Osama bin Laden notified the world that he had chemical and nuclear weapons, but would only use them if the United States used them first. A few days later, the Northern Alliance captured Kabul. During additional campaigns in Afghanistan, coalition forces discovered a chemical laboratory and training films

depicting chemical agents killing dogs, but they did not discover any chemical weapons.

### **Russian Use of a Nonlethal Chemical Agent**

Throughout 2002 Russia continued to experience terrorist incidents related to its war in Chechnya. In October Chechnyan terrorists took over a Moscow theater and held over 900 people hostage. The terrorists strapped on explosives and positioned themselves among the hostages. After failing to obtain their objectives, the terrorists began executing hostages. Russian security forces flooded the theater with a chemical agent identified in the press as fentanyl, a nonlethal gas. Russian special forces stormed the theater and most of the terrorists were killed by gunfire; however, over 118 of the hostages died from the effects of the gas.

At first the Russian government kept the identity of the gas secret from the world and from its own medical facilities. It was not until a week after the incident that the Russians finally identified the gas, leading to a strong public debate about whether Russia had violated the Chemical Weapons Convention.

### **Operation Iraqi Freedom**

Dissatisfied with Iraq's noncompliance with the UN mandates that concluded the Persian Gulf War, the United States repeatedly bombed Iraq throughout 2000 and 2001. Of particular concern to the United States was Iraq's failure to report all its chemical warfare research and weapons productions. Iraq reportedly restricted its chemical weapons programs after

UN monitors withdrew from the country.

In 2002 both President George W Bush and British Prime Minister Tony Blair publicly warned the UN that Iraq had reinstated its weapons of mass destruction program. The UN, however, was unconvinced of the charges and debated the need for a new resolution concerning Iraq. In the meantime, the US Congress authorized President Bush to use force against Iraq if necessary. A large coalition force assembled in Kuwait in preparation for future military action. This force was well equipped with the latest chemical defense equipment.

Unable to obtain UN support for a military attack, the United States launched Operation Iraqi Freedom in 2003 with an unsuccessful attempt to eliminate Saddam Hussein. Allied troops then invaded Iraq, taking great precautions in case chemical weapons were used against them. Although a few Scud missiles were launched against forces in Kuwait, none contained chemical agents. The occupation of Iraq was quickly accomplished without any known use of chemical weapons. On May 1 President Bush publicly declared the end of hostilities; however, US casualties continued to occur. At least one roadside attack involved the detonation of a sarin-filled artillery projectile, but no casualties resulted.

Despite an extensive search, no large stockpiles of chemical weapons were discovered in Iraq. Investigators did find protective masks, nerve agent antidote injectors, decontamination kits, and protective clothing. Interviews with captured Iraqi scientists and other leaders indicated that the chemical weapons programs had been shut down prior to the invasion.

Some commentators speculated that the Iraqis had purposely misled the world about their weapons of mass destruction as a bluff to prevent military action against them. Other reports indicated that some of the chemical weapons may have been shipped to Syria or other countries friendly to Iraq. Because the Chemical Weapons Convention prohibited the use of tear gas in combat, world debate arose when US forces used tear gas during security operations in Iraqi cities. However, the Chemical Weapons Convention allowed tear gas use in domestic riot control, which is how the United States had used it.

Iraqi insurgents stepped up terror attacks on the streets of Taji, north of Baghdad, in February and March 2007. On February 21, 2007, insurgents used conventional explosives to detonate a tanker carrying chlorine, creating a toxic cloud. Baghdad security spokesperson General Qassim Atta reported five deaths from the blast and 148 casualties from the gas. The following day, suspected Sunni Arab insurgents detonated a car carrying an explosive device attached to chlorine gas canisters on a road leading to Baghdad's airport. The gas cloud killed two and left 33 others feeling ill. The chlorine gas cloud suggested new and coordinated tactics with unconventional weapons. A raid in Fallujah in late February 2007 revealed a homegrown factory for car bombs and cylinders of toxic chlorine gas and other chemicals. This discovery caused the United States to fear future tactics with chlorine bombs, and fears were confirmed as additional attacks involving three chlorine gas car bombs were carried out in western Iraq on March 16, 2007, killing two and injuring hundreds of Iraqi civilians.

## SUMMARY

Although chemical warfare has not been repeated on the scale that occurred during World War I, incidents of chemical weapons used on the battlefield have continued throughout the 20th and into the 21st century, and the potential for a major escalation remains. Terrorist attacks with chemical weapons are an even more likely scenario.

To prevent such an event, US military forces must continue to learn about chemical warfare and how to accomplish their missions on chemical battlefields and chemical terrorist fronts throughout the world. In the words of General Pershing, "we can never afford to neglect the question"<sup>48(p77)</sup> of chemical preparedness again.

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