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CHEMOTERRORISM

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CHEMOTERRORISM

INTRODUCTION

Chemical warfare agents are substances that may kill, injure or incapacitate people through their toxic effects. Of the thousands of known toxic chemicals, only about 70 have been used or stockpiled as chemical weapons in this century and only a few of these are considered suitable for use today by terrorists.(1) Nonetheless, many of these agents have legitimate alternative uses and are thus readily available from a number of sources or are relatively easy to manufacture.

CHEMICAL WEAPON USE AND THE CHEMICAL WEAPONS CONVENTION

Although the history of chemical weapons dates to Antiquity, their first large-scale use was during the First World War, where they caused more than 90,000 fatalities.(2) Public outrage over the use of chemical weapons in this conflict led to the signing of the Geneva Protocol in 1925, which prohibited their use in warfare, but not their production or accumulation.(3) Furthermore, several nations, including Canada, agreed to the Protocol with the following reservations: the Protocol would be binding only on relations with other Parties to the Protocol, and if any enemy state failed to observe the provisions of the Protocol, it would cease to be binding on relations with such states.(4) Nevertheless, Italy (a signatory to the Protocol) and

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(1) Organisation for the Prohibition of Chemical Weapons (OPCW), *Chemical Warfare Agents*, 1997, www.opcw.org/chemhaz/cwagents.htm. The States Parties to the Chemical Weapons Convention set up the OPCW to oversee the implementation of its provisions.

(2) OPCW, *A Brief History of Chemical Disarmament*, 1999, www.opcw.org/Basic/briefup.htm. For more information on the history of chemical weapons development and use, please refer to the "History of Chemical Warfare" section at the end of this paper.

(3) *Ibid*.

(4) William H. Barton, *Research Development and Training in Chemical and Biological Defence within the Department of National Defence and the Canadian Forces*, National Defence Canada, 31 December 1988, www.vcds.dnd.ca/bcdrc/barton/bartonenglish.pdf.

Japan (a non-signatory nation) both used chemical weapons in Ethiopia, and in Manchuria and China, respectively. In addition, both the Allies and the Axis accumulated vast stockpiles of chemical agents during World War II, although there is no evidence these were ever deployed in this conflict.[(5)] Research continued on chemical weapons through the Cold War, with tremendous advances in lethality. At the same time, stockpiles continued to grow around the world. Chemical weapons were again used in the late 1980s during the Iran-Iraq war.[(6)] But as consensus for international disarmament grew, so did support for stronger controls on chemical weapons.

After several decades of negotiation, the Chemical Weapons Convention – a new treaty designed to supplement the Geneva Protocol – was opened for signature in January of 1993. Canada was among the original signatory nations and subsequently passed the *Chemical Weapons Convention Implementation Act* in 1995. The Convention bans all use, development, production, acquisition, stockpiling and transferring of chemical weapons. According to the Convention, chemical weapons include not only the agents themselves but also any munitions and devices designed for their dispersal.[(7)] The Convention defines toxic chemicals as "…any chemical which, through its chemical effect on living processes, may cause death, temporary loss of performance, or permanent injury to people and animals." Plants are not mentioned in this definition; as a result, the use of defoliating agents – such as Agent Orange – is not prohibited. Incendiary agents, such as napalm, are also not included among the agents banned by the Convention because their effects are achieved through thermal energy and not the toxic properties of the substances themselves.[(8)] Although prohibited for use in warfare, Riot Control Agents (RCAs) – such as tear gas and pepper spray – may be used domestically for law enforcement purposes under the Convention. In addition, viruses and bacteria that produce toxins are not covered by the Convention, but instead are prohibited for use as weapons under the Biological and Toxin Weapons Convention.[(9)]

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(5) OPCW (1999), *A Brief History of Chemical Disarmament*.

(6) OPCW, *Fact Sheet 1: The Chemical Weapons Convention and the OPCW – How They Came About*, 2000, www.opcw.org/factsheets/fs1.pdf.

(7) The full text of the Convention may be found on the Department of Foreign Affairs and International Trade website, www.dfait-maeci.gc.ca/nndi-agency/cwc_1-e.asp.

(8) OPCW (1997), *Chemical Warfare Agents*.

(9) OPCW, *Fact Sheet 4: What is a Chemical Weapon?* 2000, www.opcw.org/factsheets/fs4.pdf.

ACQUISITION OF CHEMICAL AGENTS

Numerous authors have commented on the ease with which subnational organizations may acquire or produce chemical weapons. Such weapons might be:

- purchased from legitimate industrial suppliers;
- stolen from military installations;
- stolen from medical or scientific research facilities; or
- obtained from state sponsors which support terrorist activities.[10]

A number of chemical agents that could potentially be used as weapons have legitimate industrial uses and may be bought from agricultural or industrial chemical supply houses.[11] For example, both phosgene and hydrogen cyanide are manufactured around the world in industrial facilities for their respective uses as a chlorinating agent and as an intermediate in acrylic polymer synthesis.[12] Several insecticides and rodenticides are widely available and highly toxic; according to some authors, these may be as dangerous as their military counterparts.[13] Because of their lower level of security, military storage facilities that house chemical agents would be much easier to penetrate than nuclear storage sites, making the theft of chemical weapons a more likely possibility.[14] Many nations, including some signatories to the Chemical Weapons Convention, have large chemical weapons stockpiles. The security of these stores varies widely both within and among states, but even in the United States some of these facilities have been described as having "less security than a local supermarket."[15] Security is even more lax at medical and scientific research facilities, where both potential weapons and their precursors may be found.

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(10) Ron Purver, *Chemical and Biological Terrorism: The Threat According to the Open Literature*, CSIS, 1995, www.csis-scrs.gc.ca/eng/miscdocs/tabintr_e.html.

(11) *Ibid.*

(12) John Pike, "Chemical Weapon Production," *Special Weapons Primer*, Federation of American Scientists, 1998, www.fas.org/nuke/intro/cw/produce.htm.

(13) Purver (1995).

(14) *Ibid.*

(15) Richard Charles Clark, *Technological Terrorism*, Devin-Adair, Old Greenwich, CT, 1980, as cited by Purver (1995).

Canada possesses no stockpiles of any chemical weapons other than those used for crowd and riot control purposes.[(16)] However, research on biological and chemical defence undertaken by the Department of National Defence (DND) at the Defence Research Establishment Suffield (DRES) requires that some stocks of agents be maintained. The DND's research, development and training programs in biological and chemical defence are reviewed annually by the Biological and Chemical Defence Review Committee (BCDRC), "…to ensure that all activities within those programs are, in fact, defensive in nature and are conducted in a professional manner with no threat to public safety or the environment."[(17)] In its most recent report, the Committee concluded that there is no evidence of duplicity within the government's chemical and biological (CB) defence programs, nor is there evidence that offence-related programs are being conducted.[(18)]

MEANS AND EASE OF PRODUCTION

Terrorist groups may also choose to produce their own chemical weapons. A decent-sized facility for the production of phosgene – a chemical agent that is relatively easy to produce – could be acquired for roughly $10 million to $14 million (U.S.).[(19)] Nerve agents are also fairly simple to manufacture; the techniques involved are similar to those used to make insecticides.[(20)] As mentioned earlier, a number of chemical agents may be manufactured using otherwise benign industrial facilities that already exist in many nations.[(21)] The ingredients used to produce many dangerous agents may have commercial applications; for example, the chemical ingredients of the nerve gas sarin are used as flame-retardants, petrol additives, plasticisers, paint solvents, ceramics and antiseptics.[(22)]

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(16) National Defence, *Canadian Forces Operations: Nuclear, Biological and Chemical Defence*, B-GG-005-004/AF-011, www.dnd.ca/dcds/dnbcd/dnbcd_home/Doctrine/book1/book1_e.pdf.

(17) Heather D. Durham (Chair), Colin R. McArthur and Kenneth L. Roy, *2000 Annual Report of the Biological and Chemical Defence Review Committee*, September 2000, www.vcds.dnd.ca/bcdrc/reports/bcdrce00.pdf, p. C-1.

(18) *Ibid.*, p. 2.

(19) Pike (1998), "Chemical Weapon Production."

(20) Elliott Hurwitz, "Terrorists and Chemical/Biological Weapons," *Naval War College Review*, 35:3 (May-June), 1982, pp. 36-40, as cited by Purver (1995).

(21) Pike (1998), "Chemical Weapon Production."

(22) "The terror next time?" *The Economist*, 6 October 2001, www.economist.com/science/PrinterFriendly.cfm?Story_ID=806202.

If a subnational group were to attempt to produce their own supplies of chemical weapons, it is generally agreed that this could be accomplished with the skills possessed by a graduate student in chemistry.(23) Much of the technical information required can be obtained from the open literature; for example, both Britain and the United States have declassified the formula for making VX nerve gas, one of the most toxic nerve agents.(24) Although agents such as sarin and VX may be manufactured with limited facilities, such an endeavour would not be totally without risk of personal injury; the inherent dangers involved in their production may be a deterrent to the use of these weapons.(25)

MODES OF DELIVERY

Greater than the challenge of producing chemical weapons is that of delivering them in an effective manner.

> …a chemical bomb exploded in a busy terminal would undoubtedly kill hundreds; an attack on a stadium full of football fans using a low-flying crop-duster-type aircraft might kill thousands; aerosol dissemination by means of a smoke generator located in a van cruising the streets might kill tens of thousands. However, to accomplish an attack on an outside target as outlined above with only a moderate degree of success would require tens of gallons of agent and appropriate, although not necessarily ideal environmental conditions.(26)

A terrorist attack involving chemical weapons may be obvious or covert. There are numerous ways to overtly deploy chemical weapons including bombs, submunitions, projectiles, warheads, and spray tanks.(27) Clandestine dissemination can be carried out in various ways, including the following three popular scenarios: (1) contamination of public water

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(23) Purver (1995).

(24) *Ibid*.

(25) *Ibid*.

(26) R.W. Mengel, "Terrorism and New Technologies of Destruction: An Overview of the Potential Risk," Appendix 2, in: *Disorders and Terrorism: Report of the Task Force on Disorders and Terrorism*, National Advisory Committee on Criminal Justice Standards and Goals, Washington, D.C., 1976, pp. 443-473, as cited by Purver (1995).

(27) John Pike, "Chemical Weapon Delivery," *Special Weapons Primer*, Federation of American Scientists, 1998, www.fas.org/nuke/intro/cw/deliver.htm.

supplies; (2) contamination of foodstuffs; or (3) aerosol or vapour dispersal in an enclosed space.[(28)]

The first scenario is unlikely to succeed for several reasons. Some agents – such as organophosphate pesticides – break down in water, rendering them useless as weapons.[(29)] The filtration and purification mechanisms of most water treatment systems also help to reduce the threat of water contamination. Furthermore, because of the great volume of water in question the chemical will be highly diluted, thus an extremely large quantity of agent is necessary to successfully poison the water supply.[(30)] However, the water supply of an individual installation may be vulnerable to attack. In such a situation, filtration as well as dilution would be less of an obstacle to potential terrorists.[(31)]

There have been several documented cases involving the contamination of foodstuffs with chemical agents. Some examples include:

- 1994: 15 deaths caused by cyanide-laced champagne in Tajikistan.
- 1989: millions of dollars of exports lost when Chilean grapes were found to be contaminated with cyanide.
- 1981: food items contaminated with herbicides in several British grocery stores.
- 1977-1989: Numerous incidents and threats of contamination of Israeli citrus exports with liquid mercury.

Aerosol dissemination of chemical weapons allows for non-explosive delivery. When using this method, enclosed spaces are ideal targets; wind direction and velocity as well as accurate weather observations are very important for a successful attack. To date, the only successful aerosol dissemination of a chemical weapon by terrorists in an enclosed space was the 1995 sarin nerve gas attack by the Aum Shinrikyō cult in the Tokyo subway. However, although this attack was intended to kill thousands, the damage was limited to 12 deaths and about 40 seriously injured people. The cult spent upwards of $30 million on research and equipment, illustrating the difficulty associated with successful mass casualty chemical weapon attacks.[(32)]

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(28) Purver (1995).

(29) *Ibid*.

(30) *Ibid*.

(31) *Ibid*.

(32) "The terror next time?" (2001).

POTENTIAL AGENTS

Chemical weapons are often divided into four groups according to the way they impact their victims. The four categories are:

- Choking agents: chlorine, phosgene, diphosgene, chloropicrin
- Blister agents: sulphur mustard, nitrogen mustard, phosgene oxime, Lewisite
- Blood agents: hydrogen cyanide, cyanogen chloride, arsine
- Nerve agents: tabun, sarin, soman, cyclosarin, VX

A. Summary Table

Causative agents	Means of exposure	Lethal dosage[33]	Rate of action	Mode of action	Effects	Antidotes / Methods of treatment	Examples of commercial uses of chemicals or precursors
Choking agents	Inhalation	3000-20000 LCt_{50}	Delayed to rapid	Damages respiratory tract, causing extensive fluid build-up in the lungs.	Shortness of breath; irritation of mucous membranes; coughing; tightness of chest Culminates in fluid build-up in lungs leading to fatal choking Vomiting, fluid build-up in lungs	No antidote once exposed Individuals should put on gas masks and other protective gear to prevent inhalation Medical responses include: • relocation to decontaminated environment • enforced rest • management of secretions in airways • oxygen therapy • prevention/treatment of pulmonary edema	Disinfectants, plastics, pesticides, solvents, chemical synthesis, dyes and herbicides
Blister agents	Skin contact and/or inhalation	Via skin exposure: 25-4500 LD_{50} Via inhalation: 1300-3200 LCt_{50}	Rapid (delayed symptoms for sulphur mustard)	Causes blisters on skin and damages the respiratory tract, mucous membranes, and eyes	Skin blistering, respiratory tract damage, burning of the eyes	Thorough decontamination using water Prevention of infection using antibiotics Application of lotions/ointments to soothe blisters Mustard has no known antidote British-Anti-Lewisite can mitigate some systemic effects of Lewisite, although it can itself cause some toxicity	Paper and rubber manufacturing, pharmaceuticals, insecticides, plastics, detergents, cosmetics, lubricants, ceramics, toiletries, waxes and polishes

(33) Approximate median lethal dosage of inhaled airborne agent given in LCt_{50} (milligrams per minute per cubic metre, or mg-min/m^3), also referred to as lethal concentration time. Approximate median lethal dosage of skin-absorbed agent given in LD_{50} (milligrams of agent per kilogram of body weight, or mg agent/kg body weight). The lower the number, the more lethal the agent.

Causative agents	Means of exposure	Lethal dosage[33]	Rate of action	Mode of action	Effects	Antidotes / Methods of treatment	Examples of commercial uses of chemicals or precursors
Blood agents	Inhalation	2000-11000 LCt_{50}	Rapid	Interferes with the absorption of oxygen into the bloodstream	Agents inhibit cell respiration; heart and central nervous system are susceptible Cyanogen chloride also greatly irritates eyes and lungs In moderate cases: • vomiting • dizziness • deeper, more rapid breathing In severe cases: • convulsions • respiratory failure • sudden loss of consciousness leading to death	Agents are highly volatile; flush eyes with water; remove contaminated clothing; rinse exposed skin with water Antidotes: intravenous administration of sodium nitrite and sodium thiosulfate for detoxification purposes Pretreatment under development in the UK	Pesticides, fumigating, electroplating, gold and silver extraction, dyes, pigments and nylon production
Nerve agents	Skin contact and/or inhalation	Via skin exposure: 10-1700 LD_{50} Via inhalation: 50-400 LCt_{50}	Rapid to very rapid	Disables enzymes responsible for the transmission of nerve impulses	Effects seen in eyes, nose and airways Nausea and vomiting also possible Twitching/convulsions Fluctuations in heart rate Loss of consciousness and seizure activity can occur within one minute of exposure in cases of exposure to high concentration of agent Eventual paralysis, death	4 steps to management of exposure to nerve agents: • decontamination • ventilation • antidotes • supportive therapy Therapeutic drug options: • Atropine and Pralidoxime Chloride • Diazepam (anticonvulsant drug) Pretreatment option: • Pyridostigmine (can increase the lethal dose threshold significantly if ingested prior to exposure and if paired with traditional therapeutic options)	Insecticides, gasoline additives, detergents, missile fuel, plastics, dyes, pigments, fire retardants, disinfectants, paint solvents, ceramics, optical brighteners, textile softeners, pyrotechnics, pharmaceuticals, fertilizers and pesticides

B. Choking Agents

Choking agents are typically dispersed as a gas and then inhaled by victims. They cause injury by attacking lung tissue and irritating the respiratory tract, including the nose and throat. Choking agents work by causing a continuous secretion of liquid into victims' lungs, effectively causing them to drown.[34] Phosgene, the most dangerous of the choking agents, is the most likely candidate for future use by terrorists. Although colourless, phosgene smells similar to newly mown hay.[35]

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(34) OPCW (2000), *Fact Sheet 4: What is a Chemical Weapon?*

(35) John Pike, "Chemical Warfare Agents," *Special Weapons Primer*, Federation of American Scientists, 1998, www.fas.org/nuke/intro/cw/agent.htm#b04.

Exposure to high concentrations of choking agents can cause death within hours but usually takes 24 to 48 hours. The symptoms of exposure during and after exposure include coughing, choking, tightness in the chest, nausea, and sometimes vomiting and headache. A symptom-free period will then follow, usually lasting from 2 to 24 hours. Thus, the symptoms of lung damage often do not manifest themselves until a few hours have passed and they are aggravated by physical exertion. Rest and medical observation are therefore essential.(36) Coughing, rapid shallow breathing, cyanosis and possibly nausea and vomiting characterize the onset of the pulmonary edema, which is what actually kills victims. As the pulmonary edema progresses, a frothing sputum develops.(37) If the victim survives more than 48 hours, he/she will usually recover. In these cases, the patient usually recovers with little or no residual damage. All contact with these agents should be avoided, specifically through the use of protective clothing, and breathing and eye protection.(38)

C. Blister Agents

Blister agents, also referred to as vesicants, are some of the most common chemical weapons; they include mustard agents, Lewisite and phosgene oxime. Vesicants initially irritate, then cause damage to their victim's eyes, respiratory tract and skin.(39) These agents burn and blister any part of the body they come into contact with, predominantly the skin, but also the eyes, mucous membranes and lungs. When inhaled, vesicants harm the respiratory tract; when ingested, they can cause vomiting and diarrhea.(40) Although only a small percentage of blister agent victims die, blindness and permanent respiratory system damage are common. Blister agents can be dispersed as a liquid, aerosol, vapour or dust.(41)

Mustard agents are characterized by a latent symptom-free period, which usually lasts several hours, depending on the quantity of agent involved, the mode of exposure and

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(36) International Programme on Chemical Safety (IPCS) & the Commission of the European Communities (CEC), *Phosgene*, International Chemical Safety Cards, 1993, www.bt.cdc.gov/Agent/Pulmonary/ipcs0007.asp.

(37) Pike (1998), "Chemical Warfare Agents."

(38) IPCS & CEC (1993), *Phosgene*, International Chemical Safety Cards.

(39) OPCW (2000), *Fact Sheet 4: What is a Chemical Weapon?*

(40) Pike (1998), "Chemical Warfare Agents."

(41) OPCW (2000), *Fact Sheet 4: What is a Chemical Weapon?*

environmental conditions.[42] As a result, exposure may initially go unnoticed. In contrast, Lewisite and phosgene oxime both work quickly; symptoms, such as coughing and burning, appear almost immediately. Like mustard agents, Lewisite provokes severe irritation of the respiratory tract, and the dead tissue that results may obstruct the victim's airway; victims are also predisposed to secondary infection because of the damage sustained.[43] Few compounds are as painful and destructive as phosgene oxime; only a few milligrams are needed to inflict severe wounds, and recovery may take up to three months.[44]

D. Blood Agents

Dispersed as a gas, blood agents enter the body by inhalation and are then distributed through the body via blood. They act to inhibit blood cells from using and transferring oxygen, thereby depriving the body of oxygen and essentially causing the victim to suffocate.[45] Symptoms include abdominal pain, nausea, vomiting, dizziness, headache, confusion, weakness, drowsiness, unconsciousness, burning sensation, sore throat, shortness of breath, and coughing.[46]

The emergence of symptoms of infection by blood agents may be delayed. For example, exposure to arsine or cyanogen chloride can lead to severe lung, eye and skin damage, but these may not manifest themselves for several hours.[47] Arsine may also impair kidney performance, while hydrogen cyanide can damage the central nervous system causing the victim's circulatory and respiratory systems to malfunction.[48] Individuals may avoid contact with these agents through the use of protective clothing as well as breathing and eye protection.

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(42) Pike (1998), "Chemical Warfare Agents."

(43) *Ibid.*

(44) *Ibid*.

(45) OPCW (2000), *Fact Sheet 4: What is a Chemical Weapon?*

(46) International Programme on Chemical Safety & the Commission of the European Communities, *Arsine*, *Cyanogen Chloride*, *Hydrogen Chloride*, *Hydrogen Cyanide, Liquefied*, International Chemical Safety Cards, 1993, www.bt.cdc.gov/Agent/Blood/ipcs0222.asp, www.bt.cdc.gov/Agent/Blood/ipcs1053.asp, www.bt.cdc.gov/Agent/Blood/ipcs0163.asp, www.bt.cdc.gov/Agent/Blood/ipcs0492.asp.

(47) International Programme on Chemical Safety & the Commission of the European Communities, *Arsine*, *Cyanogen Chloride*, International Chemical Safety Cards, 1993.

(48) International Programme on Chemical Safety & the Commission of the European Communities, *Hydrogen Cyanide, Liquefied*, International Chemical Safety Cards, 1993.

E. Nerve Agents

Nerve agents may be dispersed as a liquid, vapour, aerosol or dust. By interfering with the normal function of acetylcholinesterase (an enzyme important to the working of the nervous system), nerve agents impair the victim's muscles.(49) These agents also work quite rapidly; a lethal dose may cause death in as little as five minutes.(50) Symptoms of nerve agents will usually follow the route of exposure. For example, when the agent is inhaled, respiratory symptoms emerge first; when ingested, the first symptoms will be gastrointestinal.(51)

Nerve agents known as "G-agents" – such as tabun, soman, cyclosarin and sarin – tend to be short-lived once released, lasting only a few days; however, "V-agents" – of which VX is the most widely known – will persist in the field for longer periods of time, up to several months in very cold conditions.(52) Symptoms are uniform for all types of nerve agents; they include runny nose, watery eyes, drooling and excessive sweating, tightness of the chest, difficulty breathing, dimness of vision (pupils become pinpointed), nausea, vomiting, cramps, loss of bladder or bowel control, twitching, jerking and staggering, headache, confusion, drowsiness, coma and convulsions.(53) Full protective clothing and respiratory protection are necessary to avoid exposure to nerve agents. Antidotes to nerve agents do exist and are stocked by some ambulance teams and hospitals, but because nerve agents work so quickly, these are only effective if introduced immediately after exposure.(54)

HISTORY OF CHEMICAL WARFARE

The use of chemical weapons is generally associated with the technological advances that created modern warfare in the 20th century. The U.S. Army first used the term

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(49) Pike (1998), "Chemical Warfare Agents."

(50) OPCW (2000), *Fact Sheet 4: What is a Chemical Weapon?*

(51) Pike (1998), "Chemical Warfare Agents."

(52) Centers for Disease Control and Prevention (CDC), *Basic Facts about VX*, Public Health Emergency Preparedness and Response, www.bt.cdc.gov/Agent/Nerve/VX/VX.pdf.

(53) CDC:
- *Ibid*.
- *Basic Facts about Tabun* (GA), www.bt.cdc.gov/Agent/Nerve/Tabun/Tabun.pdf
- *Basic Facts about Soman* (GD), www.bt.cdc.gov/Agent/Nerve/Soman/Soman.pdf
- *GF: cyclohexyl sarin*, www.bt.cdc.gov/Agent/Nerve/CyclohexylSarin/CTC0005.pdf
- *Basic Facts about Sarin* (GB), www.bt.cdc.gov/Agent/Nerve/Sarin/Sarin.pdf.

(54) OPCW, *Nerve Agents*, 1997, www.opcw.org/chemhaz/nerve.htm.

"chemical warfare" in 1917 to describe "tactical warfare using incendiary mixtures, smokes, or irritant, burning, poisonous, or asphyxiating gases." By the end of World War I, the situation had changed drastically. Chemical weapons had been used extensively, and a new convention was being negotiated to reduce its use and development. However, the use of poison and disease in war, against soldiers and civilians alike, dates back much further. Below is a timeline of some key points in the history of chemical warfare.(55)

1000 B.C.	Use of arsenical smokes by the Chinese.
600 B.C.	The Assyrians poison enemy wells with rye ergot, and the Athenian magistrate Solon uses the purgative herb hellebore during the siege of Krissa.
431-404 B.C.	Spartans are reported to have used arsenic smoke during the Peloponnesian War.
637 A.D.	The Byzantine Greeks use an incendiary agent called "Greek fire" – a mixture of petroleum, pitch, sulphur and various resins – at the siege of Constantinople.
1675	The first international agreement condemning the use of poisoned weapons is the French-German Agreement drawn up in Strasbourg.
1774-1784	Discovery of chlorine and determination of the properties and composition of hydrogen cyanide.
1802	First synthesis of cyanogen chloride.
1812	First synthesis of phosgene.
1822	First synthesis of mustard agent.
1874	The Brussels Convention on the laws and customs of war imposes a general ban on poisoned weapons; it prohibits the use of poison or poisoned gases and arms, projectiles or materials that would cause unnecessary suffering.
1886	First synthesis of chloropicrin.

(55) Sources used to compile timeline:
- CBC News, www.cbc.ca/news/indepth/background/bioterrorism.html
- ABC News, www.abcnews.go.com/sections/nightline/DailyNews/timeline_biowar.html
- U.S. Army Medicine, "History of chemical warfare and current threat," www.nbc-med.org/SiteContent/MedRef/OnlineRef/FieldManuals/medman/History.htm
- Jeffrey K. Smart, "History of chemical and biological warfare: an American perspective," in "Medical aspects of chemical and biological warfare," F.R. Sidell, E.T. Takafuji and D.R. Franz (eds), Office of The Surgeon General, Department of the Army, United States of America, 1997, Chapter 2, www.nbc-med.org/SiteContent/HomePage/WhatsNew/MedAspects/Ch-2electrv699.pdf
- OPCW (1999), *A Brief History of Chemical Disarmament*.

1899	Restrictions on the development of poisoned weapons are agreed upon at the First International Peace Conference held in The Hague, at which the signatory states pledge to abstain from using projectiles that could spread "asphyxiating or deleterious gases."
1914-1918	World War I sees the first large-scale use of chemical weapons such as chlorine and mustard gases. In 1915, Germany uses gas warfare near Ypres in France. German troops used 6,000 cylinders, releasing 168 tonnes of chlorine gas on both soldiers and civilians. Soon after, Britain and France also start to use gas. By 1918, one in every four artillery shells fired contains gas of one type or another. An estimated 124,200 tonnes of chemical agents are used over the course of the war, about 90% of which were dispersed by an estimated 66 million artillery shells. The use of chemical weapons during World War I causes 1 million casualties, more than 90,000 of which are fatal.
1919	The Versailles Treaty is adopted. It includes an article reaffirming the previous agreements regarding chemical weapons, and prohibiting the manufacture or importation of such weapons as well as their means of production by Germany.
1925	The use of chemical weapons in World War I leads to the adoption of the Geneva Protocol, which prohibits the use of biological or chemical weapons in warfare, but does not ban research on the production of such agents. The protocol was broadly ratified with the exception of the United States and Japan.
1935	Italy uses chemical weapons during the Italian-Ethiopian War (Italy had ratified the Geneva Protocol in 1928). This is the first open breach of the Geneva Protocol.
1939	Japan uses mustard agent and Lewisite in its invasion of China.
1939-1945	During World War II, Germany produces 78,000 tonnes of chemical warfare agents including tabun, sarin and phosgene. Over the same period, Japan produces 8,000 tonnes and the United States produces 146,000 tonnes.
1950s	Weaponization of sarin in the United States and development of an incapacitant program.
1950s and 1960s	Development and production of a new generation of nerve agents, known as V-agents. These substances are more persistent than their forerunners, and are about ten times more poisonous than sarin.
1959-1975	Use of defoliant and non-lethal riot control agents in large quantities by the United States Army during the Vietnam War.
1967	Open use of chemical warfare agents by both parties during the Arab-Israeli Six-Day War.
1967	The Egyptians use nerve agents in combat during the Yemen Civil War (Egypt had signed the Geneva Protocol).

1970	Japan signs the Geneva Protocol.
Late 1970s	Planes and helicopters delivering aerosols of several colours attack Laos and Kampuchea. Some of these clouds are thought to be comprised of trichothecene toxins (in particular, T2 mycotoxin).
1978	A Bulgarian exile named Georgi Markov was attacked in London with a device disguised as an umbrella that injected a tiny pellet filled with ricin toxin. He died several days later.
1980s	The U.S.S.R. uses chemical warfare agents in Afghanistan.
1980-1988	Chemical weapons are used extensively during the Iran-Iraq War, mainly by Iraq.
1991	After the Gulf War, the United Nations Security Council orders Iraq to halt its biological, chemical and nuclear weapons programs. The U.N. Special Commission (UNSCOM) begins post-war inspections.
1993	The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (Chemical Weapons Convention) is adopted in Paris. To date, 174 States have signed the Convention; 143 States have ratified it. The Convention enters into force on 29 April 1997.
1995	Members of the Aum Shinrikyō religious cult release sarin gas in the Tokyo subway system, killing 12 commuters and injuring more than 5,000. Due to the poor quality of the sarin agent and an ineffective dispersal system, casualties are lower than expected. Later, the group is found to have been experimenting with anthrax and other biological agents.
1995	Canada ratifies the Convention and adopts the *Chemical Weapons Convention Implementation Act* to implement it nationally.