

Weapons of Mass Destruction

David Tin Win and Md. Al Masum*

Faculty of Science and Technology, Assumption University
Bangkok, Thailand

Abstract

Weapons of mass destruction (WMDs) are designed to kill large numbers of people at a single blow. Military usefulness is limited because their widespread destructiveness is likely to trigger extreme responses.

They were once known as 'NBC weapons' - the letters refer to nuclear, biological, and chemical weapons. Later radiological weapons were included and the collective arsenal was then called WMDs. Now WMDs include potential weapons, based on new technologies that have potentials for mass destruction, such as genetics, proteomics, artificial intelligence, and robotics.

WMD treaties have weaknesses and ambiguity because of three factors: blurred boundary between chemical and biological weapons; spread of 'dual use' technology, such as game technology; and recent technological advances, such as DNA-sequencing, genetic engineering, and nanotechnology.

This absence of clear precise treaties has induced arguments among states that think there is a moral duty to strike first and disable any state or entity deemed to be developing such weapons; and those that think they have a right to develop WMDs for 'self defense' - the Iraq standoff.

Keywords: *Aerosol, anthrax, arsine (SA), atomic bombs (A-bombs), atropine, binary weapons technology, biological weapon, blister agents, blood agents, boosted fission weapons, botulism, brucellosis, chemical weapon, cobalt bombs, co-weaponized, cyanogen chloride (CK), decontaminate, earth-penetrating nuclear weapons, enriched uranium, fission, fungi, fusion, 'G' agents, hydrogen bombs (H-bombs), hydrogen cyanide (AC), lewsite, mustards, NBC suit, nerve agents, nuclear weapon, nuclear winter, persistent, phosgene oxime, prions, plutonium, proteomics, radiological weapon, salted bombs, sarin, smallpox, soman, tabun, thermonuclear, toxins, 'V' agents, virus.*

Introduction

Weapons of mass destruction include nuclear, chemical, and biological weapons plus radiological weapons and some others with potential for mass destruction (FAS 2001; MCTL 2001).

A **nuclear weapon** is one with enormous destructive potential. It derives its energy from nuclear fission (disintegration, breaking) or nuclear fusion (fusing, combining) reactions.

Nuclear weapons are variously called atomic bombs (A-bombs), hydrogen bombs (H-bombs), fission bombs, fusion bombs, and thermonuclear weapons.

Chemical weapons work mainly through toxicity, which is a chemical action on life processes that can cause death, temporary incapacitation or permanent harm.

Weapons are classified as chemical ones only if toxic effects are the primary property desired. For example, propellants, explosives, incendiaries and obscurants may contain toxic chemicals, but they are not classified as chemical weapons.

* Assumption University Student. ID 442 5474

Classification as chemical weapons also depends on the intended use. Chemical weapons would mean hostile intentions. For example, some toxic chemicals, such as phosgene (COCl₂), hydrogen cyanide (HCN), and tear gas (benzoyl chloride – ΦCOCl), may be used for civil or peaceful purposes as well as for hostile purposes. Only in the latter case are they chemical weapons.

If intended target effects are due to the infectivity of disease-causing microorganisms and other replicable entities, including viruses, infectious nucleic acids, and prions, the weapons are biological weapons.

Some of these agents may generate toxins that cause pathogenicity. Such toxins can sometimes be isolated and used as weapons. Since the function of these agents is toxicity and not infectivity, they could be classified as chemical weapons, even though they could still be regarded as biological weapons.

Thus BWC covers toxins produced by living organisms, microorganisms or by any other means, including synthesis.

WMDs

Table 1 shows countries that possess MWDs, those that are pursuing MWDs, or those that are capable of acquiring MWDs.

Chemical Weapons (MCTL 2001)

Classification: Chemical weapons can be classified into two main categories by their volatility, as persistent and non-persistent agents.

A persistent agent has a low volatility, and thus dissipates very slowly. It therefore continues to present a hazard for a long time after delivery. It remains as a contact hazard or an inhalation hazard. Chemical agents that have a high boiling point and a low volatility tend to dissipate slowly and are persistent.

A non-persistent agent evaporates quickly. It disperses rapidly after release and presents an immediate but short lived hazard. They are released as airborne particles, liquids and gasses; intoxication usually results from the

inhalation of the chemical agent. Chemical agents with low boiling points and a high vapor pressure tend to dissipate quickly, and are non-persistent.

A non-persistent agent may be made persistent through a thickening process: production of a highly viscous substance by dissolving chemical agent polymers in the weapon agent. This enhances persistency and adhesive ability.

Effectiveness: The effectiveness of a chemical weapon is the “capacity of an agent to produce the maximum number of casualties or amount of disruption of operations with the least amount of agent: nuclear fusion (fusing, combining) reactions”. There are many factors that can influence the effectiveness of a chemical agent; such as the amount of agent released, environmental factors, target population size, etc. Thus the effectiveness of a chemical weapon can be rather uncertain. The duration of effectiveness of a chemical agent depends on several meteorological factors, Table 2.

Characteristics:

Physical: The physical properties of chemical weapon agents cover a very wide range. The physical state can be gaseous, liquid, or solid. Vapor pressure ranges from high to negligible. Vapor densities vary from slightly lighter to much more heavy than air. The odors vary from no odor to very pungent odors. They may be soluble or insoluble in water.

Chemical: Every chemical weapons agent has its own characteristic chemical properties but a generalization can be made. Overall they are sufficiently stable to survive dissemination and transport. The reactivity and the stability of agents can vary greatly from agent to agent.

Toxicological: Overall chemical weapon agents do not always react in the same way from species to species when the same amount of the agent is used on them; a variety of factors influence reaction on a species.

Delivery: Chemical agents can be delivered in various states (gas, aerosol, liquid) and forms. Persistency is enhanced by adding a polymer.

Chemical ammunition is designed to provide a container for the chemical agent so that it can effectively reach and affect the target or target area. Chemical weapon ammunition can be made to accommodate existing weapon systems and weapons. This means that ammunition is available for use in long-range artillery, rockets (launchers and artillery), ground missiles, aerial bombs, spray tanks, mines, and grenades.

A type of technology that is often associated with chemical weapons is binary weapons technology. This technology deals with forming a chemical weapons agent just before the dispersion of the agent. When a shell or missile (binary) is launched, the compounds that are contained within the missile or shell are combined to produce a chemical weapons agent, via a chemical reaction before the missile hits the target. Binary technology allows for safer handling, storage, and disposal of chemical weapons agents. Usually nerve agents are dispersed in this way. Only USA admits having binary weapons.

Protective Equipment: The protective equipment forms a physical barrier between the body and the chemical weapons agent. The predominant protection item is a gas mask (Fig.1). They are made of a face piece, made of impermeable material, and is fitted with an aerosol filter containing a carbon filter in canister form. Mechanical filtration removes aerosols. The filter contains several elements and is capable of absorbing the majority of chemical weapons agents in aerosol form.

There are two major types of special protective clothing that provides skin protection: (i) nylon fabrics lined with butyl rubber and impermeable to liquids, and (ii) fabrics permeable to air and moisture but impermeable to chemical weapons agents. An example is an outer oil-resistant layer of fabric which has an inner layer of finely ground activated carbon, attached to plastic foam.

Decontamination: Decontamination plays a key part in the defense against chemical weapon agents. Vehicles, men, and materials that come in contact with chemical weapons agents need decontamination. Personnel

decontamination is available in a standard kit (Fig. 2). A powder, called fuller's earth, is a standard decontaminant, which functions by absorbing liquid agents. Liquid decontaminants act by dissolving the chemical weapons agent. Alcohol solutions of sodium phenolate, sodium cresolates (both used in the decontamination of nerve agents), and chloramine solutions (used in the decontamination of mustard gas and V-agents) are examples of liquid decontaminants.

Autoject devices are available for individuals recently exposed to several nerve agents. Atropine is injected into the body as soon as nerve agents have been detected. Atropine dilates the veins, stimulates the heart action, and generally purges nerve agents from the body. Pralidoxime or oxime tablets aid this. However, atropine does not always work and is known to have fatal side effects. The above are decontaminants used on personnel.

For equipment decontamination, decontaminants must be able to penetrate the contaminated material and destroy the chemical weapons agent. An example is DS2 (70% diethylene triamine, 28 ethyleneglycol monomethylether, and 2% sodium hydroxide).

Superheated steam, hot air, and boiling also do the job. Ground decontamination can be done by covering the contaminated area with a bleaching powder which releases chlorine, a general purpose decontaminant.

Types of Chemical Weapons:

- Blistering agents
- Blood agents
- Choking agents
- Nerve agents
- Psychotomimetic agents

(a) Blister agents (MCTL 2001)

What are blister agents? Blister agents, usually called mustard agents, are chemical weapon agents that cause wounds, which resemble blisters or burns (Figs. 3 and 4). In addition, mustard agents also cause severe tissue damage to the eyes, respiratory system, and internal organs.

What substances belong to the blister agents? Sulfur mustard agent (bis-2-chloro ethylsulphide) (A.K.A), distilled mustard (HD),

levinstein (H) and, the nitrogen mustards (HN-1, HN-2 and HN-3), phosgene oxime (CX), lewsite (L), phenyldichloro arsine (PD), ethyldichloroarsine (ED) are some substances that are classified as blister agents

General Information: Blister agents are most likely to be used both to produce blisters and to force enemy troops to wear protective equipment thereby reducing their efficiency. Blister agents can contaminate almost anything it touches for long periods of time. Mustard agents are able to penetrate cell membranes in tissues and many other materials (wood, rubber, plants, etc.). Blister agents in their pure states are colorless and almost odorless. But some have rotten onion or mustard smell. Mustard agents, like other chemical weapons, can be thickened by adding a polymer. At room

temperature mustard agents are liquids that are stable with a low volatility. In warmer climates persistence of mustard agents is less but higher concentrations of vapor occur.

Mustard agents are hydrolyzed in water at fast rates, yielding polyalcohols and harmful hydrochloric acid. But mustard agents in aqueous solutions (especially bleaching powder and chloramines solutions) hydrolyze into harmless compounds.

The mustard agents are very much alike and the majority of the information on blistering agents, in the above paragraph and in the following section on sulfur mustard, is true for most mustards. The small differences between the blistering agents are mentioned under the individual blistering agent, described below.

SULFUR MUSTARD

General Information

Chemical name	Sulfur mustard or distilled mustard (HD)
Molecular formula	bis-2-chloroethylsulphide
Melting point	14.4°C

Sulfur mustard is the best known of the mustard agents. Sulfur mustard and other mustards are able to penetrate cell membranes in tissues and many other materials (wood, rubber, plants, etc.).

What does sulfur mustard do? Sulfur mustard is a 'bifunctional alkylating agent'. It contains two reactive chloroethyl functional groups. It has the ability to covalently bond to other substances. The chlorine atom is split off from the chloroethyl group and attaches to a reactive sulphonium ion. This ion can in turn bind to a wide variety of biological molecules, such as nucleic acids, proteins, and nucleotides. Sulfur mustard can create cross-links between nucleotides of DNA and RNA, thus inhibiting their replication.

As stated above, sulfur mustard is a bifunctional agent, so the second thing that sulfur mustard does is to form links between molecules. By means of alkylation, sulfur mustard destroys large amounts of living tissue within an individual. Overall, sulfur mustard and other mustards cause massive cellular mutations.

Symptoms of sulfur mustard poisoning: Sulfur mustard attacks the skin, eyes, lungs, and gastro-intestinal tract. Internal organs, mainly the blood-generating organs, can also be badly damaged. Symptoms of sulfur mustard toxicity do not show up until two to twenty-four hours after the initial exposure occurs. By that time the damage has already been done.

The symptoms of sulfur mustard typify those of all of the other mustards, mostly because they extend over a wide range. The symptoms of a mild sulfur mustard poisoning are aching eyes (massive amount of tearing), inflammation of the skin, irritation of the mucus membrane, coughing, sneezing, and hoarseness. Overall mild poisonings do not need medical treatment. However, excessive exposure is incapacitating and demands immediate medical attention. Loss of sight, nausea, severe respiration difficulty, vomiting, blistering of the skin, and diarrhea are some of the effects.

The liquid state of sulfur mustard causes severe injuries whereas exposure to sulfur mustard in the gas state usually has mild injuries. Depending on the level of exposure, mustard agents will cause different levels of skin inflammation, ranging from small irritation to a skin necrosis that is so comprehensive that no blisters occur.

Protection and Decontamination: For general protection, a NBC suit (Nuclear Biological Suit) and a gas mask should be worn. All exposed materials should be thoroughly cleaned with water or the appropriate substance. Exposed materials that cannot be cleaned should be disposed of properly to prevent further contamination.

NITROGEN MUSTARDS (HN-1, HN-2 and HN-3)

General Information

Chemical names	HN-1: 2.2' dichloro-triethylamine HN-2: 2.2' dichloro-diethyl methylamine HN-3: 2.2'.2-trichloro-triethylamine
----------------	--

Like sulfur mustard, they are derivatives of ammonia, all are liquids that are dark in color and oily, and are much more dangerous than sulfur mustard. The nitrogen mustards inflict the most damage on the lower intestinal tract. The most toxic and most volatile of the

three nitrogen mustard is HN-2 but HN-3 is used more because of its stability. Other than the fact that it is slightly more dangerous than sulfur mustard, everything else about the nitrogen mustard is the same.

PHOSGENE OXIME (CX)

General Information

Chemical names	dichloroformoxime
----------------	-------------------

Phosgene oxime exists as both liquid and solid forms. The only difference between this and the other mustards is that its 'typical

mustard agent effects' occur immediately after exposure.

LEWSITE (L)

General Information

Chemical names	dichloro (2-chloro-vinyl) arsine
----------------	----------------------------------

Lewsite is a dark oily liquid with a small odor of geranium. Lewsite is quick acting and causes more pronounced blistering than most other blistering agents. Once inside the body, it causes systemic destruction. Another major difference between this and other mustards is that it produces low blood

pressure, lung swelling, and bowel troubles. An exposure to high concentrations of Lewsite can kill in ten minutes whereas a low exposure can cause symptoms to occur in thirty minutes. Lewsite is a mustard agent that is most often mixed with other chemical weapons agents to produce an extreme effect on an individual.

PHENYLDICHLOROARSINE (PD)

General Information

Chemical names	Phenyldichloroarsine
----------------	----------------------

Phenyldichloroarsine has no odor or color, and is most often in a liquid state. Beside the fact that its is slightly less effective than

sulfur mustard and that it makes use of a gas mask more difficult, all other characteristics of it are like that of sulfur mustard.

ETHYLDICHLOROARSINE (ED)

General Information

Chemical names	ethyldichloroarsine
----------------	---------------------

On exposure it causes an immediate irritating effect. Other than this fact and the fact

that it is less persistent than sulfur mustard, it is like sulfur mustard in every other way.

(b) Nerve Agents (MCTL 2001)

What are nerve agents? Nerve agents are highly toxic chemical agents that poison the nervous system and disrupt vital bodily functions.

What substances belong to the nerve agents? There are five major substances that are classified as nerve agents, which are made up of two main groups: the 'G' agents and the 'V' agents. The 'G' agents are tabun, soman, cyclohexylmethyl phosphonofluridate (GF) and sarin. The 'V' agent is typified by the agent known as VX.

General properties of nerve agents: Nerve agents are colorless in a pure state and yellowish if impure. Some have a fruity odor.

They are generally slightly soluble in water, but hydrolysis is slow. They are slightly soluble in lipids and are rapidly inactivated by strong alkalis and chlorinating compounds.

A technology associated with nerve agents is binary weapons technology, where nerve agents are formed in a container (a missile, bomb, etc.) via a chemical reaction brought about by mixing the appropriate chemical reactants, just before being dispersed.

Nerve agents are very much alike, so the majority of the information is contained in the above facts on blistering agents and the following sections on nerve agents in general.

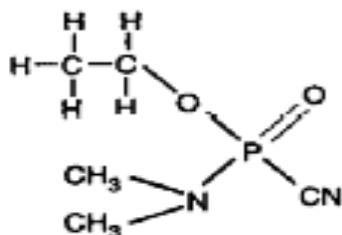
What do nerve agents do? A distinctive characteristic of the nerve agents is their high toxicity levels and their rapid effect on an exposed individual. Nerve agents (whether as a gas, aerosol, or liquid) enter the body through inhalation, through the skin, or through digestion. The time for onset of effects depends mainly on the entry route. Because of the possibility of rapid diffusion throughout the body via the lungs, lung entry affect time is shortest. Skin entry may take slightly longer to kick in because they have to penetrate the blood vessels.

Upon entry, the nerve agent inhibits the normal actions of acetylcholinesterase, a chemical within the body whose normal function is breaking down acetylcholine that causes muscular contraction. Thus nerve agents cause violent muscle spasms.

Protection and de-contamination: A good source of protection from nerve agents, although not always useful, is a protective NBC (nuclear Biological Chemical) suit and a gas mask. It must be stressed that these protective articles of clothing do not always work against some nerve agents.

'G' AGENTS: Overall the 'G' agents tend to be non-persistent. Some of these agents can be thickened by a polymer. The 'G' agents tend to be volatile liquids.

TABUN (GA)

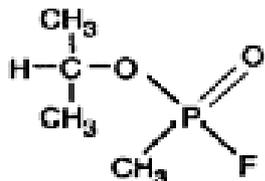


Chemical name	o-ethyl dimethylamidophosphorylcyanide
Molecular formula	(CH ₃) ₂ N-P(=O)(-CN)(-OC ₂ H ₅)

Molecular weight	162.1
Melting point	-50°C
Boiling point	247°C

Tabun is the easiest of the nerve agents to manufacture. It is almost totally odorless and colorless in a pure state.

SARIN (GB)

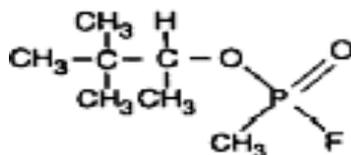


Chemical name	isopropyl methylphosphonofluoridate
Molecular formula	$\text{CH}_3\text{-P(=O)(-F)(-OCH(CH}_3)_2)$
Molecular weight	140.1
Melting point	-56°C
Boiling point	147°C
Binary weapon compound	methylphosphoryldifluoride (DF) + isopropanol

Sarin is a volatile nerve agent. It is one of the easiest nerve agents to treat using an auto-

injector. It is also more soluble in water than any of the other nerve agents.

SOMAN (GD)



Chemical name	pinacolyl methylphosphonofluoridate
Molecular formula	$\text{CH}_3\text{-P(=O)(-F)(-CH(CH}_3)_2\text{C(CH}_3)_3)$
Molecular weight	182.2
Melting point	-42°C
Boiling point	167°C
Binary weapon compound	methylphosphoryldifluoride (DF) + pinacolylalcohol

Soman is a moderately volatile nerve agent, which enters the body through inhalation or skin contact. Soman also has a slightly fruity

odor. This agent is the toughest to treat with the auto-injector because of a process that causes acetylcholine esterase to go through.

CYCLOHEXYL METHYLPHOSPHONOFLURIDATE (GF)

Chemical Name	Cyclohexyl methylphosphonofluoridate
Molecular Formula	$\text{CH}_3\text{-P(=O)(-F)(cyklo-C}_6\text{H}_{11})$
Molecular Weight	180.2
Melting Point	<-30°C
Boiling Point	92°C (At 10 mm Hg)

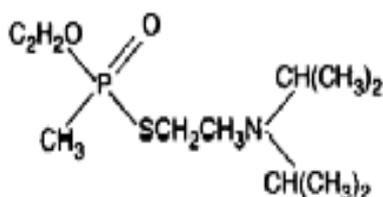
GF has a very low volatility and generally enters the body through contact with

the skin or inhalation.

'V' AGENTS

Overall the "V" agents are non-volatile and thus tend to be highly persistent. When compared with the "G" agents the "V" agents are much more lethal and persistent. In general "V" agents enter the body by skin contact or inhalation when a gas.

VX



Chemical Name	O-ethyl S-diisopropylaminomethyl methylphosphonothiolate
Molecular Formula	CH ₃ -P(=O)(-SCH ₂ CH ₂ N[CH(CH ₃) ₂] ₂)(-OC ₂ H ₅)
Molecular Weight	267.4
Melting Point	-39°C
Boiling Point	300°C
Binary Weapon Compound	O-ethyl O-2-diisopropylaminoethyl methylphosphonite (QL)+ sulfur

VX is a high persistent but non volatile substance that is much more powerful than any of the "G" agents. One disadvantage to VX is that it is highly flammable under some conditions.

BLOOD AGENTS (Militarily Critical Technologies List, MCTL. Part II. 2001)

Blood agents, including cyanogen agents, are agents that are absorbed into the body through the action of breathing. Once in the body and blood stream they cause lethal damage by acting on the enzyme called cytochrome-oxidase.

What Substances Belong to the Blood Agents? Some of the major substances that belong to the chemical weapons agents known as the blood agents are hydrogen cyanide (AC) or hydrocyanic acid (HCN), cyanogen chloride (CK), and arsine (SA).

Nuclear Weapons (NATO Handbook Part I. 1996; Sublette 2002)

The problem of controlling nuclear technology has been of central importance to the human race since the day fission was

discovered in 1938. The world was convulsed by war, paranoia, and totalitarian cruelty when the discovery was made. Thus the advance of theoretical possibility into actuality was inevitable. It is fortunate that the only role has been to close World War II, instead of opening a new one. Table 3 shows the status of nuclear powers and their nuclear capabilities as of 01 January 1999.

Types of Nuclear Weapons: Classification of nuclear weapons is based on the nuclear reactions that provide their destructive energy, and on design details. The division of nuclear weapons into fission bombs and fusion bombs is popular, but not entirely satisfactory. Weapon design is more complex than this simple classification implies. All nuclear weapons so far invented require fission to initiate the explosive release of energy. Weapons that incorporate fusion fuel can do

so in various ways, with different intended effects.

A variety of names are used for weapons that release energy through nuclear reactions - atomic bombs (A-bombs), hydrogen bombs (H-bombs), nuclear weapons, fission bombs, fusion bombs, thermonuclear weapons (not to mention "physics package" and "device").

Pure Fission Weapons: These are weapons that use only fission reactions as a source of energy. Fission bombs operate by rapidly assembling a sub-critical configuration of fissile material (plutonium or enriched uranium) into one that is highly supercritical. The base reaction is one where neutron population multiplies, an example is shown in figure 5, where the neutron population is enhanced by a factor of 3 at each step - a nuclear chain reaction with a neutron multiplication factor of 3. If the chain reaction is controlled, energy for peaceful purposes may be obtained. But if the chain is not controlled, explosions occur with enormous destructive potential. The original atomic bombs tested in 16 July 1945 (device name: Gadget, test name: Trinity) and dropped on Japan on 6 August 1945 (Little Boy, over Hiroshima) and 9 August 1945 (Fat Man, over Nagasaki) were pure fission weapons.

These are the easiest nuclear weapons to design and manufacture, and the capability to do so is a prerequisite for developing any of the other weapon types. The U.S., Russia, Britain, France, and China are the five declared nuclear powers. Israel, India, South Africa, and Pakistan also have the capability. India has tested a fission bomb, while Israel and South Africa are suspected of having tested one.

There are practical limits to the size of pure fission bombs. Larger bombs require more fissionable material, which:

1. becomes increasingly difficult to maintain as a sub-critical mass before detonation and
2. makes it harder to assemble into a high efficiency supercritical mass before stray neutrons cause pre-detonation.

The largest pure fission bomb ever tested appears to have been the U.S. 500 kt Ivy King (15 November 1952). The device exploded in this test was the Mk-18 Super Orally Bomb ("SOB").

Combined Fission / Fusion Weapons: Fusion reactions may be used to enhance the destructive effects of fission weapons. All weapons that use fusion require a fission bomb to provide the energy to initiate the fusion reactions. This does not necessarily mean that fusion generates a significant amount of the explosive energy, or that explosive force is even the desired effect.

Boosted Fission Weapons: This is the earliest application of fusion to useful weapons. A few grams of a deuterium - tritium (D-T) gas mixture are included in the fissile core center. When the bomb core undergoes enough fission, it becomes hot enough to ignite the D-T fusion reaction which accelerates, producing an intense burst of high-energy neutrons that causes a correspondingly intense burst of fissions in the core.

This greatly accelerates the core fission rate and allows fission of the core material to a much higher percentage before it blows apart. Typically a maximum of about 20% of the material in an average sized pure fission bomb will split before the reaction ends (it can be much lower - the Hiroshima bomb was 1.4% efficient).

A boosted fission bomb, by accelerating the fission process increases the yield 100% (an unboosted 20 kt bomb can thus become a 40 kt bomb). Only about 1% of the bomb's yield is due to the fusion reaction. This makes boosted bomb tests difficult to distinguish from pure fission tests (detecting traces of tritium is about the only way).

Today most fission bombs are boosted, including those used as primaries in true fission-fusion weapons. This is mainly because of the marked increase in yield. There are other reasons, such as reducing the weight of the fission system, and eliminating the risk of pre-detonation. Although boosting can multiply the yield of fission bombs, it still has

the same fundamental fission bomb design problems for high yield designs. The boosting technique is most valuable in small light-weight bombs that would otherwise have low efficiency. Tritium is a very expensive material to make, and it decays at a rate of 5.5% per year, but the small amounts required for boosting (a few grams) make its use feasible.

Cobalt Bombs and Other Salted Bombs: A ‘salted’ nuclear weapon is similar to fission-fusion-fission weapons. Instead of a fissionable jacket around the secondary stage fusion fuel, a non-fissionable blanket of a specially chosen salting isotope is used (cobalt-59 in the case of the cobalt bomb). This blanket captures the escaping fusion neutrons to breed a radioactive isotope that maximizes the fallout hazard from the weapon rather than generating additional explosive force (and dangerous fission fallout) from fast fission of U-238.

Different salting isotopes may be used to obtain variable fallout effects. Gold has been proposed for short-term fallout (days), tantalum and zinc for fallout of intermediate duration (months), and cobalt for long term contamination (years). To be useful for salting, the parent isotopes must be abundant in the natural element, and the neutron-bred radioactive product must be a strong emitter of penetrating gamma rays. Table 4.

The idea of the cobalt bomb (Sublette 2002) originated with Leo Szilard who publicized it in Feb. 1950, not as a serious proposal for weapon, but to point out that it would soon be possible in principle to build a weapon that could kill everybody on earth. To design such a theoretical weapon a radioactive isotope that can be dispersed world wide before it decays is needed. Such dispersal takes many months to a few years, so the half-life of Co-60 is ideal.

Effects of a Nuclear Weapon (Glasstone and Dolan 1977; Thirteen WNET 2003): The energy produced per gram is millions of times greater for nuclear explosives as compared to chemical explosives. Nuclear explosions cause high temperatures - tens of millions of degrees

Celsius. On explosion of a nuclear weapon, the bomb's material reaches equilibrium temperature within a microsecond. During equilibration, about 75% of the energy is emitted as primary thermal radiation, mostly soft x-rays. The rest of the energy is mostly kinetic energy in rapidly-moving weapon debris. The fraction of energy produced as blast and as light depends on the interaction of the x-rays and debris with the surroundings. In general, the denser the medium around the bomb, the more it will absorb, and the more *brisant* the shockwave will be.

If a nuclear detonation occurs in air near sea-level, most of the soft x-rays in the primary thermal radiation are absorbed within a few feet. Some energy is reradiated in the ultraviolet, visible light and infrared, but most of the energy heats a spherical volume of air, and forms the fireball. Fig. 6.

In a high altitude burst, where the air density is low, the soft x-rays travel long distances before they are absorbed. The energy is so diluted that the blast wave may be half as strong or less. The rest of the energy is dissipated as a more powerful thermal pulse.

Nuclear Winter: The famous TTAPS (Turco, Toon, Ackerman, Pollack, and Sagan) proposal concerns a potential ‘nuclear winter’ that is caused by the absorption of sunlight when large amounts of soot are injected into the atmosphere by the widespread burning of cities and petroleum stocks destroyed in a nuclear attack.

Air Bursts and Surface Bursts: Contrary to popular belief, the most destructive effect of a nuclear weapon would not be obtained if it is exploded right in the middle of its target - i.e. ground level. Generally nuclear weapons are designed to explode above the ground - as air bursts (the point directly below the burst point is called the *hypocenter*). Surface (and sub-surface) bursts can be used for special purposes.

The explosion sends out a shock wave like an expanding soap bubble. In an *air burst*, where the explosion occurs above the ground, the bubble expands and when it reaches the ground it is reflected - the shock front bounces

off the ground to form a second shock wave traveling behind the first, at a faster rate. The reflected shock wave catches up with the direct shock wave and they form a single reinforced wave.

If local fallout is desired, or if the blast is intended to destroy a buried or very hard structure like a missile silo or a dam, *surface bursts* are used. Shock waves are transmitted through the soil more effectively if the bomb is exploded in immediate contact with the soil.

Exploding a bomb below ground level, *sub-surface bursts*, can be even more effective for producing craters and destroying buried structures. It can also eliminate thermal radiation and substantially reduce the range of blast effects. The problem is getting the bomb underground.

Earth-Penetrating Nuclear Weapons: Owing to the use of the earth as a very strong cover for command and logistics both by terrorist groups and some countries, low-yield earth-penetrating nuclear weapons that can punch over one hundred feet into the earth have been developed (Nelson 2001). Such weapons may have been used in the Gulf war, to destroy Iraq's underground bunkers; and also in Afghanistan, to flush out Al Qaeda.

Biological Weapons (NATO Handbook Part II. 1996)

Infectious diseases contracted naturally have had a significant impact on military operations throughout history. Biological agents have been used to a limited extent during recent military conflicts (for example, dispersion of plague bacilli during World War II and use of trichothecene mycotoxins 'yellow rain' in Southeast Asia); however, their use probably dates from antiquity.

The World Health Organization (WHO) has published guidelines for handling epidemics caused by biological weapons (WHO epidemic response guidelines, 2000).

Classification of Biological Agents:

Bacteria are small free-living organisms. Most may be grown on solid or liquid culture media. The organism

structure consists of nucleus, cytoplasm, and cell membrane. Reproduction is by simple division. The diseases they produce often respond to specific therapy with antibiotics.

Viruses require living cells in which to replicate, and are therefore strongly dependent upon the cells of the host which they infect. They produce diseases that generally do not respond to antibiotics but which may be responsive to antiviral compounds. But there are only a few available, and those are of limited use.

Rickettsiae are microorganisms which have characteristics common to both bacteria and viruses. Like bacteria, they possess metabolic enzymes and cell membranes, utilize oxygen, and are susceptible to broad-spectrum antibiotics. They resemble viruses in that they grow only within living cells.

Chlamydia are obligatory intracellular parasites incapable of generating their own energy source. Like bacteria, they are responsive to broad-spectrum antibiotics. Like viruses, they require living cells for multiplication.

Fungi are primitive plants that are capable of anaerobic growth, draw nutrition from decaying vegetable matter, and do not utilize photosynthesis. Most fungi form spores, and free-living forms are found in soil. The spore forms of fungi are operationally significant. Fungal diseases may respond to various antimicrobial.

Toxins are poisonous substances that are produced and derived from living plants, animals, or microorganisms; some toxins may also be produced or altered by chemical means. Toxins may be countered by specific antisera and selected pharmacologic agents.

The following intrinsic features of biological agents influence their potential for use as weapons: infectivity; virulence; toxicity; pathogenicity; incubation period; lethality; transmissibility; and stability. The unique ability of many biological agents is to multiply in the body and actually increase their effect.

Some Biological Warfare Agents:
Anthrax, Botulinum Toxins, Brucellosis

Cholera, Clostridium Perfringens Toxins Congo - Crimean Hemorrhagic Fever, Ebola Haemorrhagic Fever, Plague, Q Fever, Ricin, Rift Valley Fever, Saxitoxin, Smallpox, Staphylococcal Enterotoxin B Trichothecene Mycotoxins, Tularemia, Venezuelan Equine Encephalitis (U.S., FDA. 2003).

Anthrax is a zoonotic disease caused by *Bacillus anthracis*. There are two types of this disease: cutaneous anthrax and inhalation anthrax. (WHO. Anthrax surveillance and control 2000).

Cutaneous anthrax develops when a bacterial organism from infected animal tissues becomes deposited under the skin. Cutaneous anthrax causes a small elevated lesion on the skin that becomes a skin ulcer, and is frequently surrounded by swelling or edema. The lymph gland near the lesion may also swell. Lesions that occur on the neck or the eye may be complicated. The incubation period varies from one to seven days.

Inhalation anthrax is caused by inhaling the bacterial organism into the lungs. A progressive infection follows. 10,000 spores of anthrax, could affect 80% fatality in a population, and is thus considered a lethal dose. Less than one microgram is invariably fatal within five days to a week after exposure.

According to an estimate by the US Congress's Office of Technology Assessment, 100 kilograms of anthrax, released from a low-flying aircraft over a large city on a clear, calm night, could kill one to three million people.

An epidemic of inhalation anthrax in its early stage with nonspecific symptoms could be confused with a wide variety of viral, bacterial, and fungal infections. Progression over 2-3 days with the sudden development of severe respiratory distress followed by shock and death in 24-36 hrs definitely indicates inhalation anthrax.

Botulism is caused by intoxication with any of the seven distinct neurotoxins produced by the bacillus, *Clostridium botulinum*. The toxins are proteins with molecular weights of approximately 150,000, which bind to the pre-synaptic membrane of neurons at peripheral cholinergic synapses to prevent release of acetylcholine and block neurotransmission.

The blockade is most evident clinically in the cholinergic autonomic nervous system and at the neuromuscular junction. A biological warfare attack with *botulinum* toxin delivered by aerosol would cause symptoms similar to those observed with food-borne botulism.

In pure form, the toxin is a white crystalline water-soluble substance that decays rapidly in open air. Symptoms of inhalation botulism may begin as early as 24-36 hours following exposure or as late as several days. Initial signs and symptoms include generalized weakness, lassitude, and dizziness. Diminished salivation with extreme dryness of the mouth and throat may cause complaints of a sore throat. Urinary retention may also occur. Motor symptoms usually are present early in the disease; cranial nerves are affected first with blurred vision, photophobia, diplopia, and ptosis.

Development of respiratory failure may be abrupt. Mucous membranes of the mouth may be dry and crusted. Neurological examination shows flaccid muscle weakness of the palate, tongue, larynx, respiratory muscles, and extremities.

Smallpox virus is an orthopoxvirus with a narrow host range confined to humans. The virus exists today in only two laboratory repositories in the U.S. and Russia. Appearance of human cases outside the laboratory would signal use of the virus as a biological weapon.

The virus is transmitted by direct (face-to face) contact with an infected case, and occasionally by aerosols. Smallpox virus is highly stable and retains infectivity for long periods outside of the host. The incubation period is typically 12 days (range, 10-17 days). The illness begins with a prodrome lasting 2-3 days, with generalized malaise, fever, rigors, headache, and backache.

The eruption of chickenpox (varicella) is typically centripetal in distribution (worse on trunk than face and extremities) and characterized by crops of lesions in different stages on development. Chickenpox papules are soft and superficial, compared to the firm, shotty, and deep papules of smallpox. Chickenpox crusts fall off rapidly and usually leave no scar.

A related virus, monkeypox, clinically resembles smallpox and causes sporadic human disease in West and Central Africa. Monkeypox occurs only in forested areas of West and Central Africa as a sporadic, zoonotic infection transmitted to humans from wild squirrels.

Brucellosis is a systemic zoonotic disease caused by one of four species of bacteria: *Brucella melitensis*, *B. abortus*, *B. suis*, and *B. canis*. These bacteria are small gram-negative, aerobic, non-motile coccobacilli that grow within monocytes and macrophages. They reside quiescently in tissue and bone-marrow, and are extremely difficult to eradicate even with antibiotic therapy. Their natural reservoir is domestic animals, such as goats, sheep, and camels (*B. melitensis*); cattle (*B. abortus*); and pigs (*B. suis*). *Brucella canis* is primarily a pathogen of dogs, and only occasionally causes disease in humans.

Humans are infected when they inhale contaminated aerosols, ingest raw or unpasteurized infected milk or meat, or have abraded skin or conjunctival surfaces that come in contact with the bacteria. Laboratory infections are quite common, but there appears to be no human-to-human transmission.

Clostridium perfringens is a common anaerobic bacterium associated with three distinct disease syndromes; gas gangrene or clostridial myonecrosis; enteritis necroticans (pig-bel); and clostridium food poisoning. Each of these syndromes has very specific requirements for delivering inocula of *Clostridium perfringens* to specific sites to induce disease, and are thus not feasible as a biological warfare agent.

There are however, at least 12 protein toxins elaborated, and one or more of these could be produced, concentrated, and used as a weapon. Waterborne disease is conceivable, but unlikely. The alpha toxin would be lethal by aerosol. This is a well characterized, highly toxic phospholipase *Clostridium*. Other toxins from the organism might be co-weaponized to enhance effectiveness. For example, the

epsilon toxin is neurotoxic in laboratory animals.

Biological Weapons Characteristics: Low visibility, high potency, easy delivery, and accessibility are the ideal characteristics of biological weapons. To be useful as biological weapons, diseases must be highly lethal (if delivered efficiently), and robust (making aerosol delivery feasible).

Delivery of the agent in a form in which it will infect large numbers of people is the primary difficulty in mounting a biological attack. The first point in efficient delivery concerns particle size. For example, an attack using anthrax would require the creation of aerosol particles of a precise size. Large aerosol would be filtered out by the respiratory system. Small aerosol would be inhaled, but exhaled again. The second point concerns withstanding dispersion by the weather; and the third point concerns packaging the anthrax so that it would remain active. But on the whole, biological weapons can be manufactured easily and quickly.

Lack of Clear Treaties – The Iraq Standoff

In the past, efforts had been made, in the form of treaties, to prevent MWD development and use. These treaties have loopholes. The major causes are:

(1) **Blurred boundary** between chemical and biological weapons (e.g. prions which are not organisms but simple single-molecule proteins, and could thereby be considered either chemical or biological)

(2) **Spread of ‘dual use’ technology** through commercial channels that could easily be put to military use.

(3) **Technological advances** after formulation of the treaties:

(a) **DNA-sequencing and genetic modifying** methods, where biological entities may be modified to become, or induced to make poisonous substances (or carry them). For example, altering the well-understood *E. coli* bacterium to generate anthrax prions, which is considered to be technically feasible, and hard to detect.

(b) *Nanotechnological/molecular engineering* methods to generate new molecules with lifelike characteristics, or to exude substances those are useful as chemical weapons.

The danger of efficient and miniature weapons-grade *robotics* to control all of the above, *artificial intelligence* and *computer graphics* to train, brainwash, motivate and guide human carriers of such weapons to their targets, were also not anticipated.

'Dual use' technology is quite worrying. A peaceful innocent technology can be converted into a lethal one quite easily. Such technology will be very difficult to cover by treaties. A classic example is the modern video game technology. It may be sufficient to train terrorists or suicide bombing, kamikazes, including detection evasion.

For these reasons, the more generic phrase 'weapons of mass destruction' came into use, and is now generally used by international institutions, such as *The Security Council*, in assessing and describing threats.

Thus clear precise and unambiguous treaties are extremely difficult to formulate, if not impossible to do so. Absence of clear treaties invites arguments, such as the current Iraq standoff. Self-interest driven interpretation of ambiguous outdated treaties, made Bush believe that there is a duty to strike first and disable any state or entity deemed to be developing such weapons (Moral Duty); and Iraq assume they have a right to develop such weapons (Divine Right). Moral Duty versus Divine Right is the basic factor that has currently turned the world into a very dangerous place.

Conclusion

Presently there is a strong indication that terrorist groups, like Al Qaeda, plan to inflict greater numbers of casualties in countries whom they identify as enemy states. The 9/11 WTC incident is a classic example. The continuing possibility of attacks, using nuclear, biological, or chemical weapons, is an ongoing concern in the area of national security, especially for the West.

One way of viewing weapons of mass destruction is to compare national technologies. Compared to a nation that has only a cavalry, those nations that have tanks would be like having WMDs. The tribe with bows and arrows faces a weapon of mass destruction when their rival has a Hotchkiss gun or a howitzer.

Most WMDs are held secretly. The greater the destructive force, the greater the need for secrecy. For example, for secrecy the first atomic bomb was referred to as simply the "gadget." The revealed potentialities of weapons are always less than the actual potentials. The secrets about "little boy" were not exposed until after it was used openly.

Many WMDs are hidden under names that are the exact opposite of what they really are. Places where weapons are manufactured hide under names belying the true operations within. "Little boy" was not "little" in terms of destruction.

It is ultimately the mind that precedes the action and it is the mind that can control actions. Irrespective of the destructive power, or the lethal potential, it is the mind that can utilize these for good or bad. Let us hope and pray that man will not be foolish enough to wipe himself off the surface of the earth.

Acknowledgement

The authors are grateful to semester 2/2002 General Chemistry (CT 1101) students of Assumption University for inspiration through their assignment reports on WMDs.

References

- FAS. 2001. Federation of American Scientists, <http://fas.org/nuke/>
- Glasstone, S.; and Dolan, P. J. 1977. **The Effects of Nuclear Weapons (3rd ed.)**, US Government Printing Office, <http://nuketesting.enviroweb.org/nukeffect>
- Militarily Critical Tech. List (MCTL). 2001. Weapons of Mass Destruction Technologies. <http://fas.org/irp/threat/mctl98-2/index.html>

Militarily Crit. Tech. List (MCTL) Pt. II. 2001. Weapons of Mass Destruction Technologies Chemical Weapons Technology <http://www.fas.org/irp/threat/mct198-2/p2sec04.pdf>

NATO. 1996. **Handbook on the Medical Aspects of NBC Defensive Operations (Part I - Nuclear)**, Washington, DC. <http://www.fas.org/nuke/guide/usa/doctrine/dod/fm8-9/1toc.htm>

NATO. 1996. **Handbook on the Medical Aspects of NBC Defensive Operations (Part II – Biological)**. Washington, DC. <http://www.fas.org/nuke/guide/usa/doctrine/dod/fm8-9/2toc.htm>

Nelson, R.W. 2001. Low-Yield Earth-Penetrating Nuclear Weapons. FAS Public Interest Report. The Journal of the Federation of American Scientists. <http://fas.org/faspir/2001/v54n1/weapons.htm>

Sublette, C. 2002. High-En. Weapons Archive. <http://nuketesting.enviroweb.org/hew/> <http://www.fas.org/nuke/intro/bw/intro.htm>

Thirteen WNET. 2003. Secrets of the Dead. http://www.pbs.org/wnet/secrets2/case3_clues.html

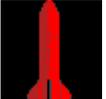
U.S., FDA. 2003. Center for Food Safety and Applied Nutrition. “The Bad Bug Book”. <http://vm.cfsan.fda.gov/~mow/intro.html>

WHO. Guidelines for the Surveillance and Control of Anthrax in Humans & Animals WHO/EMC/ZDI/98.6 <http://www.fas.org/nuke/intro/bw/whoemczdi986.htm>

WHO. Recommended guidelines for epidemic preparedness and response: Ebola Haemorrhagic Fever WHO/EMC/DIS/97.7 <http://www.fas.org/nuke/intro/bw/whoemcdi977>

Table 1. States Possessing, Pursuing or Capable of Acquiring MWD

This resource provides a list as of 2000. Not every state listed here is actively pursuing or proliferating WMD systems, nor is the list necessarily complete.

STATE	NUCLEAR	CHEMICAL	BIOLOGICAL	MISSILE
Algeria				
Belarus				
Bulgaria				
Chile				
China				
Cuba				
Ethiopia				
Egypt				
France				

India				
Indonesia				
Iran				
Iraq				
Israel				
Kazakhstan				
Laos				
Libya				
Myanmar				
North Korea				
Pakistan				
Romania				
Russia				
Serbia				
South Africa				
South Korea				
Sudan				
Syria				
Taiwan				
Thailand				
Ukraine				
Vietnam				
United Kingdom				
United States				

Sources and Methods: <http://fas.org/nuke/guide/>

- [A Chemical Weapons Atlas](#) By E.J. Hogendoorn Bulletin of the Atomic Scientists October 1997, Vol. 53, No. 5
- [Chemical and Biological Weapons: Possession and Programs Past and Present](#)
- "The Specter of Biological Weapons" by Leonard A. Cole [Scientific American](#) December 1996
- Defense Nuclear Agency, [Biological Weapons Proliferation](#) (Ft. Detrick, Md.: US Army Medical Research Institute of Infectious Diseases, April 1994), page 46.
- [Sources on Tables Listing Countries of Chemical and Biological Weapon Concern](#) Proliferation of Weapons of Mass Destruction: Assessing the Risks Office of Technology Assessment OTA-ISC-559, 1994 [Angola, Argentina, Brazil, Chad, Cuba, El Salvador, Mozambique, Nicaragua, Peru, and Philippines are mentioned by a few cited sources as possessing chemical weapons, but most sources do not include them as chemical weapon states, which would bring the total to 29 chemical weapons states].

Table 2. Factors That Influence the Effectiveness of a Chemical Weapon

<http://www.fas.org/irp/threat/mct198-2/p2sec04.pdf>

Factor	Effects
Winds	Winds can allow chemical agents to disperse rapidly in certain topographical areas. Lack of winds can cause a build up in the concentration of certain chemical agents.
Temperature	High temperatures tend to decrease the persistency of some agents while cold temperatures tend to increase the persistency of some agents.
Rain	Rain affects chemical agents by disposing some, diluting others, or by promoting hydrolysis in some agents. Overall rain may dispose of some particular agents but others will most likely still be able to be used.
Atmospheric Stability	When the temperature of the air is higher than that of the ground, chemical agents in a vapor state tend to stay persistent for longer periods of time. However when the temperature of the air is lower than that of the ground, chemical agents in the vapor state tend not to persist as long as they usually do.

Table 3. Status of Nuclear Powers and Their Nuclear Capabilities
Data as of 01 January 1999

		US	Russia	United Kingdom	France	China	Israel	India	Pakistan
Weapons	Stockpile	12,000	21,000	200	+500	+500	200	+50	~25
	Deliverable	6,750	5,426	200	444	~325	200	-50	-25
ICBM	Number	500	756			20			
	Warheads	2,000	3,590			20			
	Type	<u>MM II</u> : 0 <u>MM III</u> : 500 <u>MX PK</u> : 50	<u>SS-18</u> : 180 <u>SS-19</u> : 160 <u>SS-24</u> : 46 <u>SS-25</u> : 360 <u>SS-27</u> : 10			<u>DF-5</u> : 20			
IRBM, MRBM	Number					130	100	0	
	Warheads					130	100	0	
	Type					<u>DF-3</u> : 50 <u>DF-4</u> : 30 <u>DF-21</u> : 50	Jericho 1 : 50 Jericho 2 : 50	Agni	
SLBM	Number	432	260	58	64	12			
	Warheads	3,456	1,036	~200	384	12			

	Type	Trident-1: 192 Trident-2: 240	SSN-8: 152 SSN-18: 176 SSN-20: 20 SSN-23: 64	Trident-2: 58	M-4 : 48 M-45: 16	JL-1 : 12			
		Ohio : 18	Delta I: [12] Delta III: 11 [13] Delta IV : 4 [7] Typhoon: 1 [6]	Vanguard : 3	Inflexible : 3 Triumphant : 1	Xia-SSBN : 1			
Strategic Bombers	Number	138	69						
	Weapons	~1,300	800						
	Type	B-2 : 12 B-1B: 70 B-52: 56	Tu-95H6 : 28 Tu-95H16: 35 Tu-160 : 6						
Theater Bombers	Number				60	170			
	Weapons				60	170	100	50	25
	Type				M 2000N : 60 S Etandard 0	H-5 : 20 H-6 : 120 Q-5 : 30	F-4 F-16	Jaguar MiG-27	F-16

Sources and Methods <http://www.fas.org/nuke/guide/summary.htm>

- [START I Aggregate Numbers of Strategic Offensive Arms](#) (As of January 1, 1999)
- [NRDC Nuclear Notebook @ Bulletin of the Atomic Scientists](#)
- [Current World Nuclear Arsenals @ CDI](#)

Table 4. Candidate Salting Agents

Isotope	Abundance	Product	Natural Radioactive Half-Life
Cobalt-59	100%	Co-60	5.26 years
Gold-197	100%	Au-198	2.697 days
Tantalum-181	99.99%	Ta-182	115 days
Zinc-64	48.89%	Zn-65	244 days

<http://www.fas.org/nuke/intro/bw/intro.htm>



Figure 1. Gas Mask



Figure 2. Personnel Decontamination Kit



Figures 3



Figure 4



Fig. 5



Fig. 6