Guest Articles

Defense and Destruction: Insight of Chemical-based Weapons

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Millions of deaths and the end of civilizations can be inflicted by knife, machete, fire, or even by the pen or the spoken word; but a **Weapon of Mass Destruction** (WMD) implies such a result more centrally imposed.

The term WMD first appeared in December 1937 in an address given by the Archbishop of Canterbury. However, modern usage, dates to 1945, with the insertion of the words "weapons adaptable to mass destruction" in a document signed by President Harry Truman. Subsequently, that phrase appeared in the first resolution passed by the United Nations (UN) General Assembly. Within a few years, an alternate form, "weapons of mass destruction," became the preferred usage. As such, the term became an integral part of the lexicon of post-World War-II disarmament diplomacy. After the end of the Cold War, however, the term WMD saw growing usage as it appeared an average of more than 100 times a year in the early 1990s and an average of 160 times a year in the late 1990s; but the heaviest use of this term occurred during and after the 2003 invasion of Iraq.

Despite the extensive use of the term during the past two decades, there is a widespread perception that it has no accepted definition and that it means whatever the user wants it to mean, although most of the numerous definitions of WMD are variations of 1 of 5 basic definitions.

- WMD as a synonym for nuclear, biological and chemical (NBC) weapons.
- WMD as chemical, biological, radiological or nuclear (CBRN) weapons
- WMD as CBRN and high explosive (CBRNE) weapons
- WMD as weapons that cause massive destruction or kill a large number of people, and do not necessarily include or exclude CBRN weapons
- WMD as weapons of mass destruction or effect, potentially including CBRNE weapons and other means of causing massive disruption, such as cyber-attacks.

None of these definitions is perfect, but WMD as CBRN weapons is the closest to the meaning used by the international community for international disarmament negotiations, as defined by the United Nations Common Country Assessment disarmament commission in 1948. Though this article is not comprehensive, it is meant to highlight the important WMD trends which mainly focus on chemical weapons.

Chemical weapons

Chemical weapons include toxic chemical substances and their precursors; as well as derivatives, devices and munitions, specifically designed to cause death or other harm through the toxic properties of those chemicals. There are basically two categories of chemical weapons; natural chemical defense and synthetic chemical warfare agents.

Natural Chemical Defense: Flora and fauna contain natural chemical defensive systems or mechanisms for their survival and protection upon the difficult conditions.

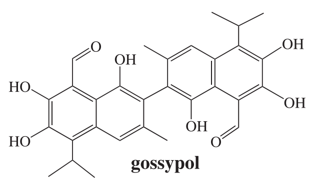
Plant defenses against pathogens and herbivores

Plants represent a rich source of nutrients for many organisms including bacteria, fungi, protists, insects, and vertebrates. Although plants lack an immune system comparable to animals, they have developed a stunning array of structural, chemical, and protein-based defenses designed to detect invading organisms and stop them before they are able to cause extensive damage.

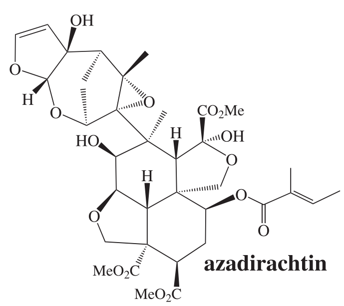
Chemical defenses: Plant chemicals can be divided into two major categories: **primary metabolites** and secondary metabolites. **Secondary metabolites** are the substances which are often involved with plant defense.

These compounds usually belong to one of the three large chemical classes: **terpenoids, phenolics**, and **alkaloids**.

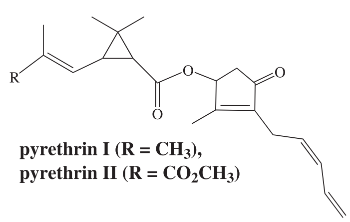
Terpenoids are classified by the number of **isoprene** units used to construct them; for example, monoterpenoids consist of two isoprene units, sesquiterpenoids with three units, diterpenoids with four units and triterpenoids with six units. Monoterpenoids and sesquiterpenoids are the primary components of essential oils, which often function as insect toxins and majority provide protection against fungal or bacterial attacks. Most of the monoterpenoids are used as insecticides; **pyrethrins**, α- and β- pinene etc. Diterpenoids including gossypol have strong antifungal and antibacterial properties. Triterpenoids such as phytoectysones and limonoids (*e.g.* **azadirachtin** and **citronella**) can disrupt the development and increase insect mortality by acting as popular insect repellents. Triterpenoids such as cardiac glycosides (*e.g.* **digoxin**) are highly toxic to vertebrate herbivores. Furthermore, **saponins** are glycosylated triterpenoids which have detergent properties and disrupt the cell membranes of invading fungal pathogens.



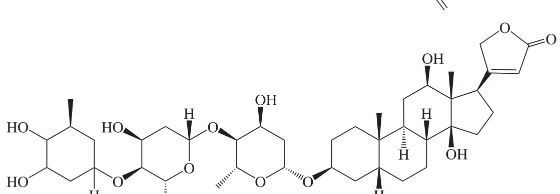
gossypol



azadirachtin

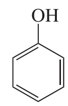


pyrethrin I (R = CH_3), pyrethrin II (R = CO_2CH_3)

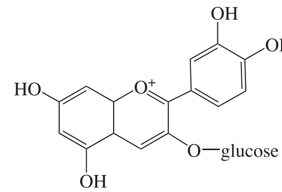


digoxin

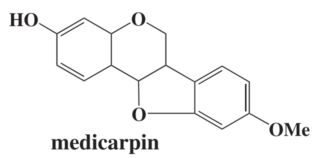
Phenolics are produced in response to pathogen attack and include a wide variety of defense-related compounds including flavonoids, anthocyanins (*e.g.* **cyanin glycoside**), phytoalexins (*e.g.* **medicarpin**), tannins, lignin and furanocoumarins (*e.g.* **psoralen**).



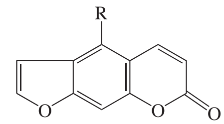
phenol



cyanin glycoside

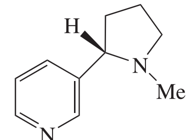


medicarpin

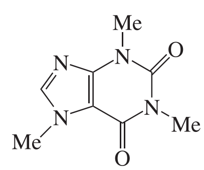


psoralen

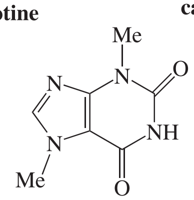
Alkaloids are a large class of bitter-tasting nitrogenous compounds that are found in many vascular plants and include **caffeine**, cocaine, morphine, **theobromine** and **nicotine**. They are derived from amino acids aspartate, lysine, tyrosine and tryptophan; many of these substances have powerful effects on animal physiology.



nicotine



caffeine



theobromine

Understanding how plants defend themselves from pathogens and herbivores is essential in order to protect our food supply and develop highly disease-resistant plant species.

Chemical defenses in animals against their predators

The chemical defense mechanisms are widely spread antipredator strategies which involve chemicals that protect the prey from predators. Within the animal kingdom, defensive chemicals are found extensively in invertebrates (*e.g.* arthropods and molluscs), with a few chemical defense strategies in vertebrates as well. Defensive chemicals are substances utilized by a prey to reduce predation risk. These chemicals include noxious, odiferous, indigestible, toxic or venomous substances that repel, deter, injure/harm or distract predators. Animals can synthesize toxins using their own metabolic processes or accumulate them from the food they consume.

Snake venom is a highly modified saliva containing zootoxins that facilitate the immobilization and digestion of prey, and defense against threats. Although snake venoms are composed of a complex collection of toxins, enzymes and non-toxic substances; they have historically been classified into three main types: **cytotoxins**, **neurotoxins**, and **hemotoxins**.

Cytotoxins are poisonous substances that destroy body cells and it leads to the death of most of the cells in a tissue or organ.

Neurotoxins are chemical substances that are toxic to the nervous system.

Hemotoxins are blood poisons that have cytotoxic effects and disrupt the normal blood coagulation process.

There are many **amphibians** (*e.g.* poison dart frog and fire salamander) that produce skin toxins using special poison glands, which are usually located at the animals' back or throughout the skin.

The larvae of Monarch butterflies accumulate toxins from the plants they inhabit, and their bright coloration allows predators to remember and avoid them.

The Scyphozoan *Stomolophu smeleagris* (Cannonball jellyfish) discharges sticky mucus when disturbed. The mucus contains discharged and undischarged nematocysts, and the toxins in the mucus are probably associated with these nematocysts. Two other species of scyphozoans and a ctenophore also discharge mucus when disturbed. Chemical defenses may be common amongst gelatinous zooplankton as well.

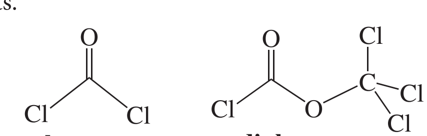
Synthetic chemical Warfare Agents

Chemical weapons are toxic chemical agents which contain solid, liquid or gaseous substances that suffocate their victims, poison their blood, blister their skin, or disrupt their nervous system. In modern warfare, chemical weapons were first used in World War-I, during which gas warfare inflicted more than one million of the casualties suffered by combatants in that conflict and killed an estimated 90,000. Since then, chemical arms have been employed numerous times: World War-II, the cold war, etc. most notably in the Iran-Iraq and Syrian civil war.

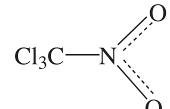
Chemical agents become weapons when they are placed into artillery shells, land mines, aerial bombs, missile warheads, mortar shells, grenades, spray tanks, or any other means of delivering the agents to designated targets. Thousands of such chemical compounds exist, but only a few dozen have been used as chemical warfare agents since 1900 due to the satisfaction of certain requirements. The compounds of most utility must be highly toxic and safe to handle; furthermore, the chemical must be capable of being stored in containers for long periods without degrading and corroding, and the chemical must be able to withstand the heat generated when the container explodes. Finally, it must be relatively resistant to oxygen and humidity in order to be effective when dispersed. Chemical agents that have been developed for military purposes are choking agents, blister agents, nerve agents, blood agents, riot control agents (*e.g.* tear gases, pepper sprays), vomiting agents, incapacitating agents and herbicides.

Choking / lung / pulmonary agents are delivered as gas clouds to the target area, where individuals become casualties through inhalation of the vapor. The toxic agent triggers the immune system, causing fluids to build up in the lungs, which can cause death by asphyxiation or oxygen deficiency if the lungs are badly damaged.

Chlorine, phosgene, diphosgene, chloropicrin, and nitric oxide are some common examples for choking agents.



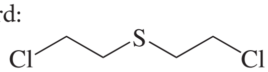
phosgene **diphosgene**



chloropicrin

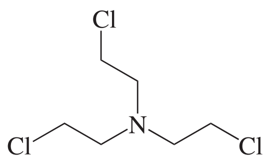
Blister agents / vesicants are delivered in the forms of liquid, aerosol, vapor and dust; such weapons burn the skin, mucous membranes, eyes, windpipe and lungs which results in large blisters on the exposed skin. The physical results, depending on level of exposure, might be immediate or might appear after several hours. Large number of casualties was inflicted; although lethal in high concentrations, blister agents seldom kill. Modern blister agents include sulfur mustard (mustard gas), nitrogen mustard, phosgene oxime, phenyldichloroarsine and lewisite.

Sulfur mustard:

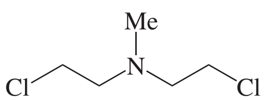


bis(2-chloroethyl) sulfide

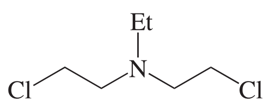
Following are the examples for nitrogen mustards:



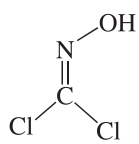
tris(2-chloroethyl) amine



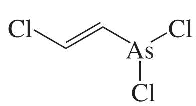
bis(2-chloroethyl)methylamine



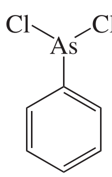
bis(2-chloroethyl) ethylamine



phosgene oxime



lewisite

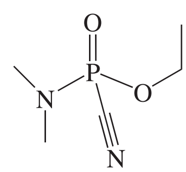


phenyldichloroarsine

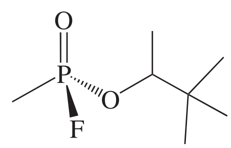
Blood agents such as arsine - AsH_3, hydrogen cyanide - HCN and cyanogen chloride – CNCl are designed to be delivered to the targeted area in the form of a vapor. When inhaled, these agents inhibit the proper utilization of oxygen within the blood cells, causing them to 'starve' thus strangling the heart.

Nerve agents contain the most lethal and important chemical weapons and they affect the transmission of impulses through the nervous system. A single drop on the skin or inhalation into the lungs can cause the brain centers controlling respiration to shut down, and muscles including the heart and diaphragm become paralyzed. Poisoning by nerve agents cause intense sweating, filling of the bronchial passages with mucus, dimming of vision, uncontrollable vomiting and defecation, convulsions, and finally paralysis and respiratory failure. Lethal doses can cause death in five minutes and these nerve agents can disperse as liquid, aerosol, vapor or dust. Organophosphorous compounds are comparatively stable, easily dispersed, highly toxic and act rapidly upon targets.

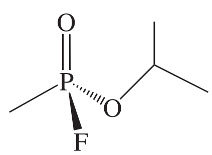
There are basically two types of nerve agents: G-series and V-series agents. G series agents were invented in Germany and those are tabun, sarin, soman, and cyclosarin. **VX** (V for venom) is the most famous V-series nerve agent developed by British chemists. V-series contains the deadliest known nerve agents which are 10 times more powerful than those of the G-series.



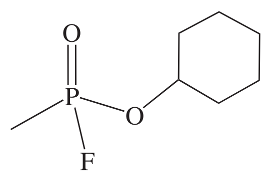
tabun



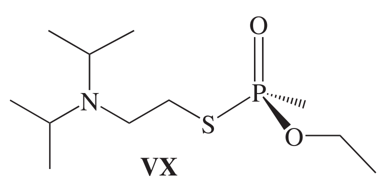
soman



sarin

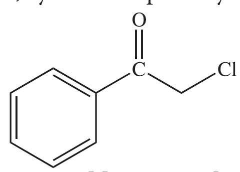


cyclosarin

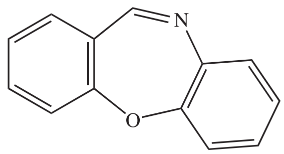


VX

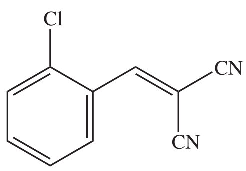
Riot control agents (*e.g.* tear gas) can produce rapid sensory irritations or physical disabling effects in humans, which disappear within a short time after the cessation of exposure. These substances disperse in either liquid or aerosol form, and absorb through lungs, skin and eyes. Tear gas and pepper sprays have been produced to control riots and unruly crowds. Commonly used tear gases are o chlorobenzylidene malononitrile (CS gas), dibenzo[b,f][1,4]oxazepane, chloroacetophenone, and chloropicrin. Chloroacetophenone, the principal component of the self-defense aerosol spray, **Mace**, mainly affects the eyes. CS gas and chloropicrin are stronger irritants that can burn the skin, eyes and respiratory tract.



chloroacetophenone



dibenzo[b,f][1,4]oxazepine



o-chlorobenzylidene malononitrile

Pepper spray, also known as **capsaicin spray** or **capsicum spray**, is a temporarily disabling aerosol that is composed partly of oleoresin capsicum, which is a chemical derived from the fruit of plants in the genus Capsicum. This results in irritation, and blinding of the eyes, inflammation of the nose, throat, and skin, and causes temporary discomfort and burning of the lungs which causes shortness of breath.

These riot-control agents are banned by the Chemical Weapons Convention (CWC) if used as "a method of warfare" but are allowed for domestic police enforcement.

In general, chemical weapons are an anti-population weapon, and its exposure levels are typically expressed as mg-minutes of agent per cubic meter of air. Chemical agents are prohibited to all State Parties by the 1997 CWC; however, there is an exception in the CWC for nonlethal chemical warfare agents used for law enforcement purposes that may loom larger in the future. Of the world's chemical weapons stockpiles declared since the CWC entered in to force, about 97% have been verifiably destroyed as of mid-2019. Therefore, all the nations shall give their highest priority to develop effective strategies to minimize man's exploration in the universe, reserving outer space for peaceful use, prohibiting weapons of mass destruction in space or on celestial bodies, and opening the mysteries and benefits of space to every nation.

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