Chem-biothreat AWARENESS for law enforcement

SAND2013-2317P

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ENGAGEMENT PROGRAM

City, country
Course Date (Change in Master Slide View)

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CHEMICAL AGENTS

SAND No. xxxx-xxxx
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Sandia National Laboratories

International Biological Threat Reduction
International Chemical Threat Reduction

OBJECTIVES

Understand the principles of toxicity and the absorption of chemical agents

Identify the main types of military chemical warfare (CW) agents and common toxic industrial chemicals or materials TICs/TIMs that could be used as weapons

- Understand the toxic mechanism of each agent
- Recognize the characteristics and clinical signs and symptoms of each agent
- Discuss how the properties of agents relate to their absorption and effectiveness
- Introduce decontamination and treatment measures for chemical agents

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OVERVIEW

Principles of Toxicity

Absorption of Chemical Agents

- Chemical and Physical Properties
- Routes of Exposure

Chemical Weapons

- Nerve Agents
- Blister Agents (Vesicants)
- Choking Agents (Pulmonary)
- Blood Agents

Other Chemical Agents

- Riot Control Agents
- Dual-Use Chemicals
  - *Toxic Industrial Chemicals/Materials (TICs, TIMs)*
  - *CW Precursors and other illicit use*

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PRINCIPLES OF TOXICITY

Toxicity Depends on Dose

Chemical	Beneficial Dose	Toxic Dose
Aspirin	300-1000 mg	1000-30,000 mg
Vitamin A	500 units/d	50,000 units/d
Oxygen	20% in air	50-100% in air
Water	~1-2 L/day	~13 L

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison from a remedy."

- Paracelsus (1493-1541)

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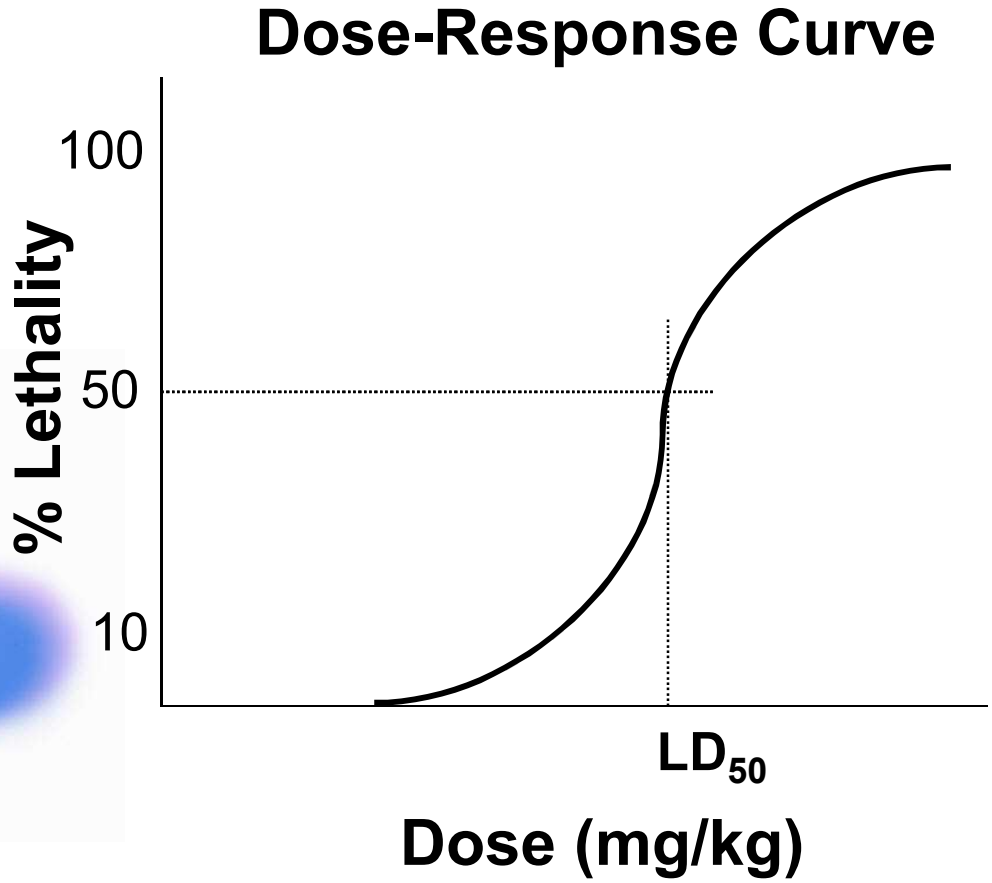
PRINCIPLES OF TOXICITY

Toxicity is Measured by Lethality

- LD_{50} (mg/kg)

"Lethal Dose 50%"



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PRINCIPLES OF TOXICITY

An extremely wide range of toxicities exists

Agent	LD_{50} (mg/kg)
⬅ Ethanol	7060
NaCl	3000
Formaldehyde	800
Caffeine	192
Nicotine	1
Dioxin	0.0001 ➡

http://news.bbc.co.uk/2/hi/health/4041321.stm

2004, Viktor Yushchenko was poisoned with dioxins

PRINCIPLES OF TOXICITY

LCt_{50} (mg•min/m^3) is used to describe toxicity of chemicals by inhalation

Agent	LCt_{50}
Chlorine	6000
Phosgene	3000
Sulfur Mustard	1500
Sarin	100
VX	10

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Toxicity has many variables

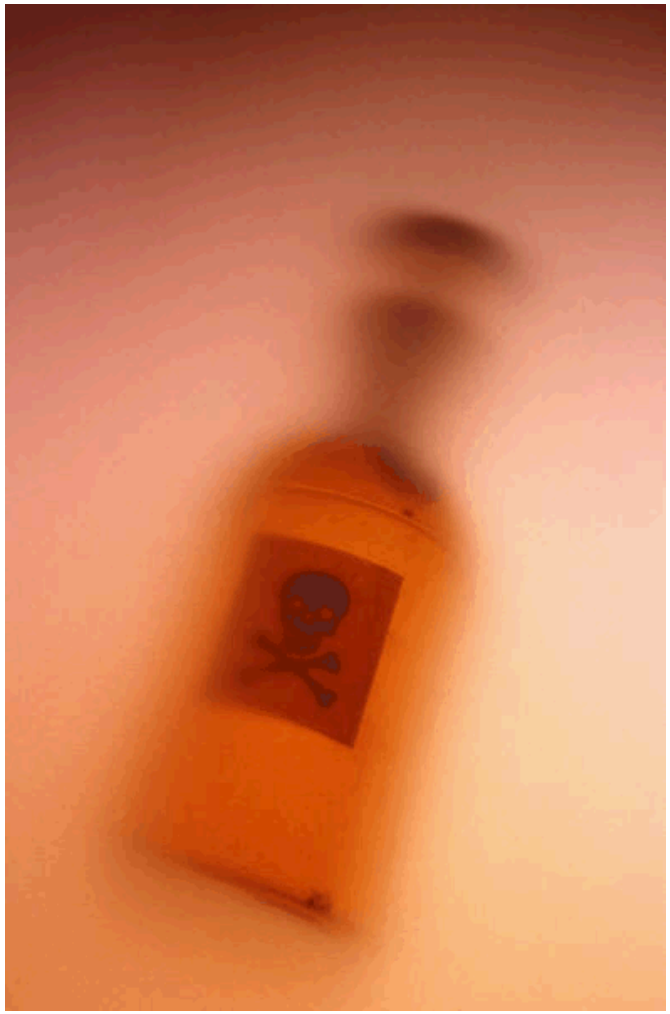
PRINCIPLES OF TOXICITY

Acute

- Cause harm right away

Chronic

- May only see effects after extended exposure, or later in life after repeated exposures



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ACUTE TOXICITY

Chemical weapons

- Sarin
- VX

Highly toxic industrial or laboratory chemicals and poisons

- Cl_2
- Cyanides
- Strychnine

Need to know when you are dealing with acute toxins

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CARCINOGENS

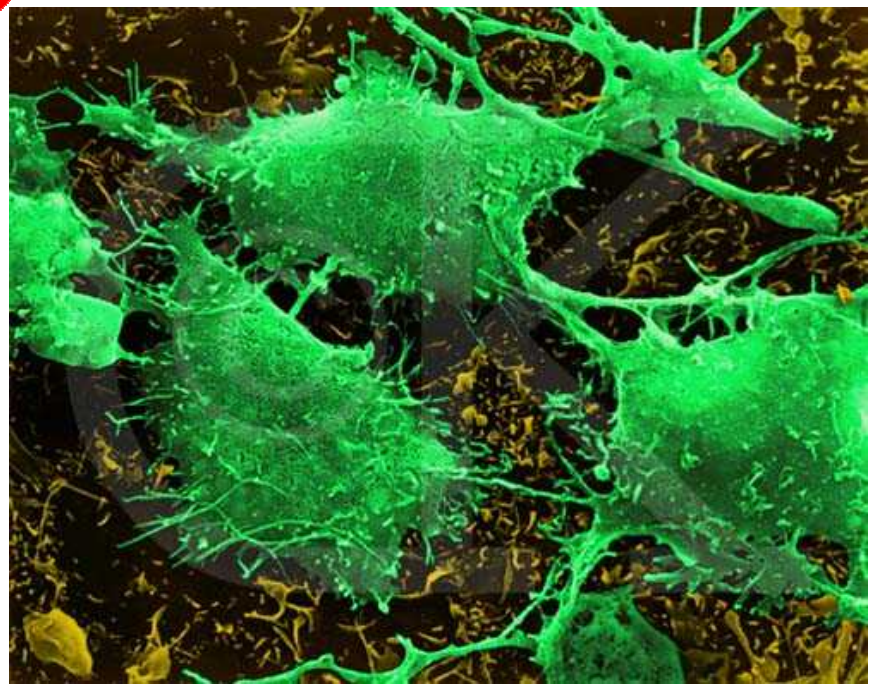
Chronically Toxic

- Vinyl chloride (liver cancer)
- Asbestos (mesothelioma)

Carcinogenicity of most chemicals is untested

- Precautions taken may consider amount and frequency of use

Treat known carcinogens as particularly hazardous



http://www.alternative-cancer.net/images/Cancer_cell,%20brain.jpg

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ORGAN-TARGETING

Neurotoxins

- Ethanol, Hg, CS_2, xylene, *n*-hexane

Reproductive and Developmental Toxins

- Harm fertility or reproductive ability
- Harm fetus

Other Organs

- Liver, kidneys, lungs, etc.
- Chlorinated or aromatic hydrocarbons, some metals

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IRRITANTS, ALLERGENS, AND CORROSIVES

Irritants

- Effects are local and reversible

Allergens (and sensitizers)

- Cause a reaction of the immune system

Corrosives

- Effects are local
- Acids and bases
  - *pH ≤ 2 or ≥ 12.5*
- React with and damage living tissue

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OVERVIEW

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- **Chemical and Physical Properties**
- **Routes of Exposure**

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ABSORPTION OF CHEMICAL AGENTS

Chemical and Physical Properties

Physical State

Vapor Pressure & Volatility

Solubility

Vapor Density

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PHYSICAL STATE

Solid

- Definite shape and volume
- Small particles become an aerosol (smoke)

Liquid

- Indefinite shape, definite volume
- Small particles can be a spray or aerosol
- Boiling point – temperature at which a liquid transitions to a gas

Gas

- Indefinite shape and volume

VAPOR PRESSURE & VOLATILITY

Amount of vapor that comes off of a solid or liquid

- High vapor pressure = high volatility
- Low boiling point = high volatility

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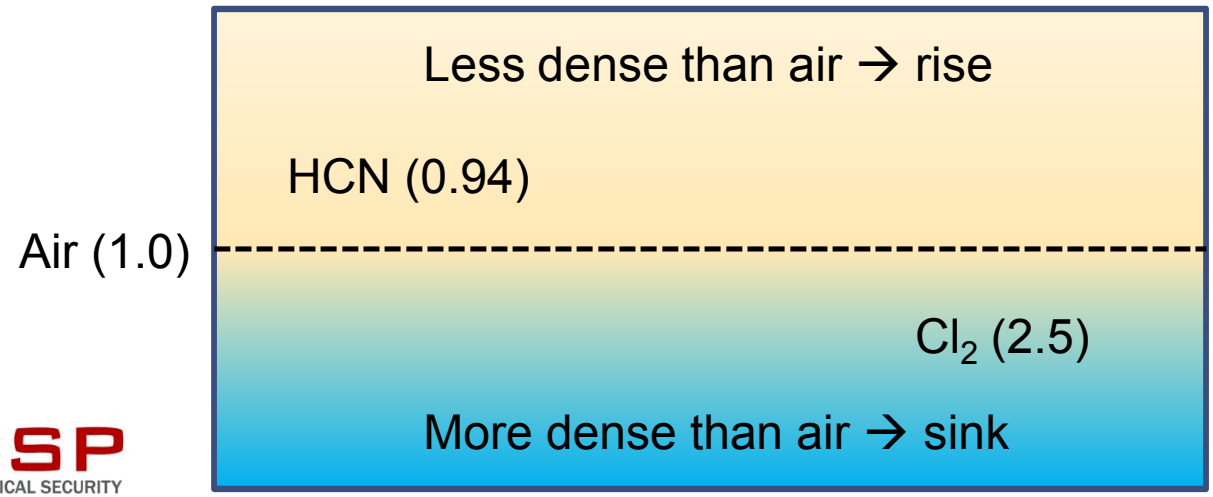
SOLUBILITY

Amount of one substance (solute) that will form a homogeneous mixture with another (solvent)

- Things tend to be either soluble in water or soluble in oil, but not both

VAPOR DENSITY

The density of a vapor relative to air (1.0) at a given temperature and pressure



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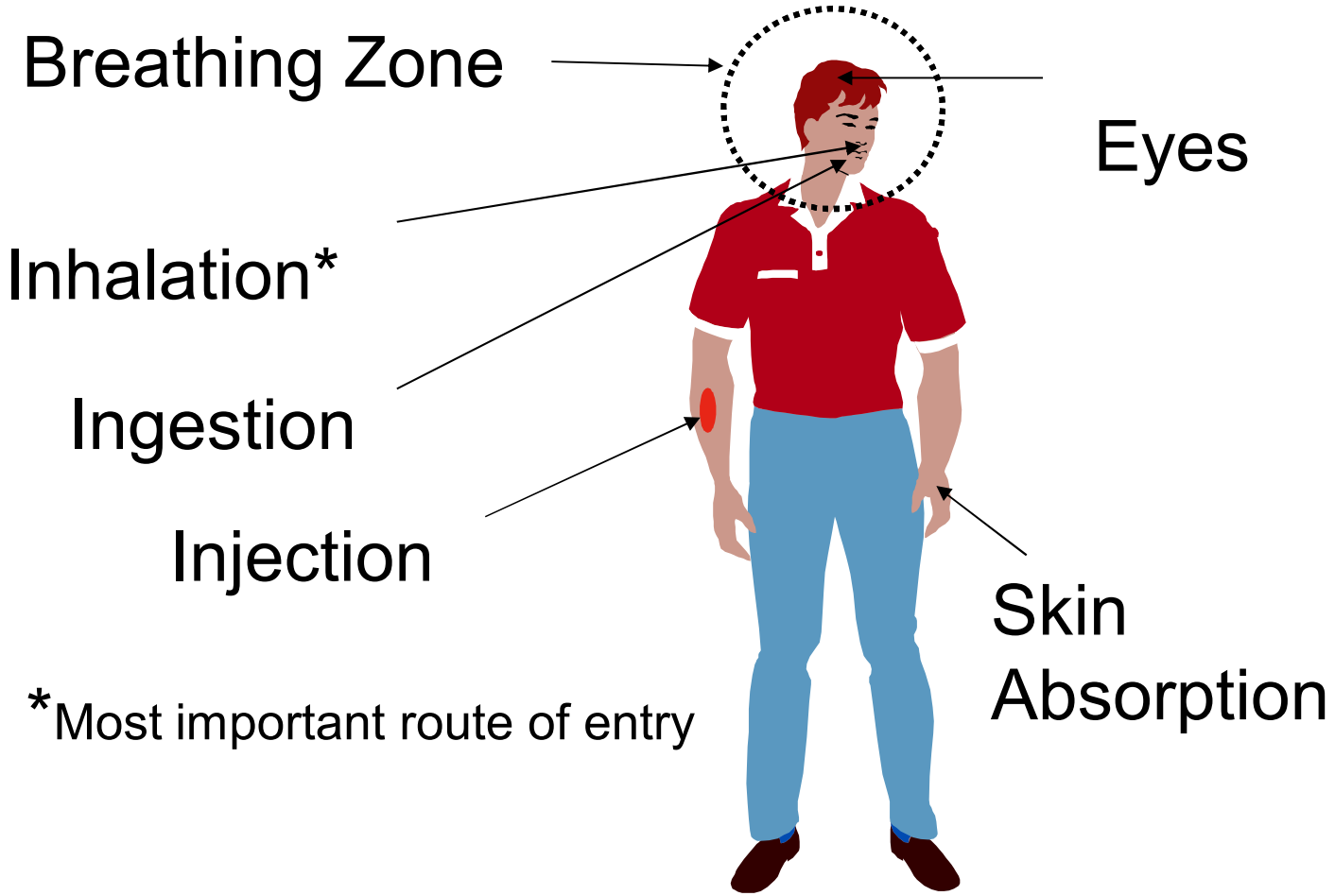
ABSORPTION OF CHEMICAL AGENTS

Routes of Exposure



*Most important route of entry

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INHALATION

Gases and Vapors

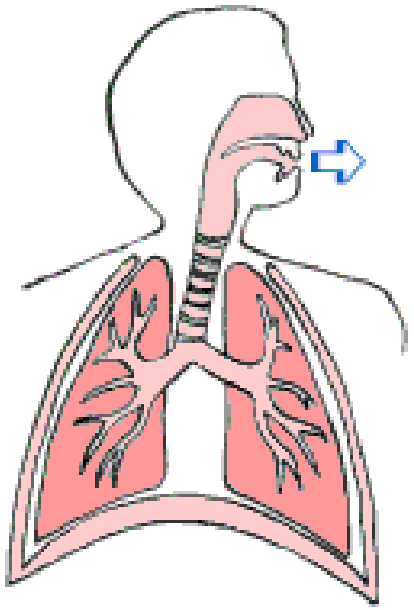
- Influenced by respiration rate, concentration, duration
- Key factors for exposure
  - *Solubility and reactivity*

Mists, Aerosols, Powders/Dusts

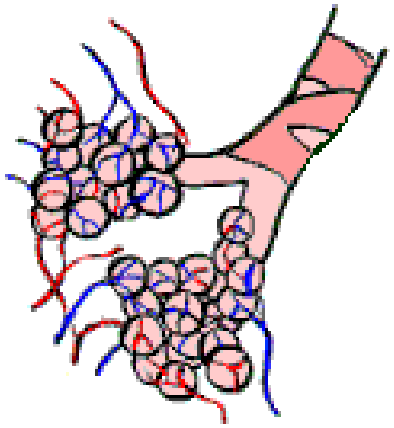
- Key factors for exposure
  - *Solubility and particle size*

Possible effects

- Local
  - *Lung tissue damage*
  - *Respiratory tract irritation*
  - *Airway constriction*
  - *Fluid build-up (edema)*
  - *Examples: Chlorine, phosgene*
- Systemic
  - *Transfer point to bloodstream*
  - *Examples: Sarin, hydrogen cyanide*



Alveoli



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INHALATION

Aerosol penetration into the lung depends on particle size

Size (micrometers)	% Deposition in Upper Airway	% Deposition in Alveoli
> 20	100	0
10 – 20	80	20
5 – 10	50	50
0.1 – 5	10	90

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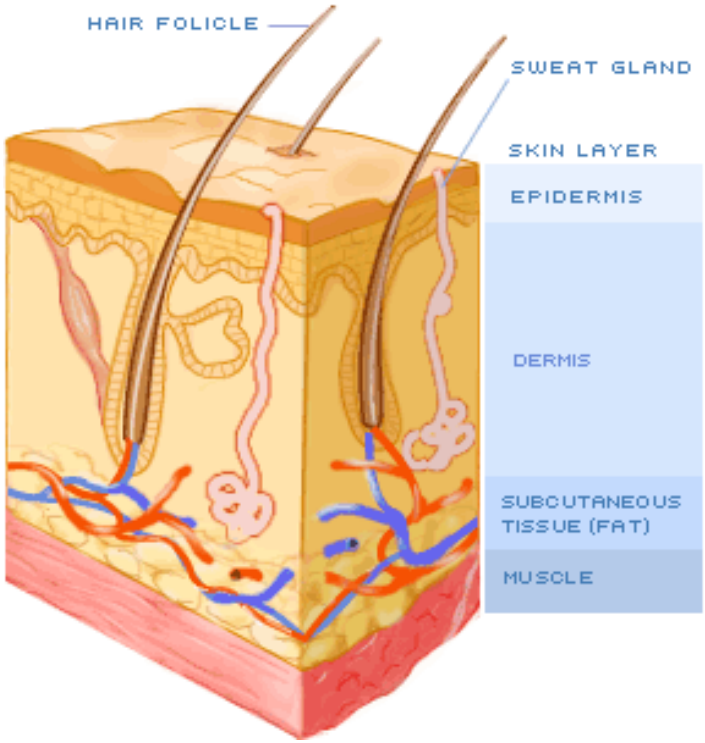
SKIN ABSORPTION

Absorption depends on skin

- Site of contact
- Skin thickness
- Temperature and blood flow
- Skin condition
  - *Example: broken or wet skin*



Absorption depends on chemical

- Solubility (in fat/water)
- Molecular size
- Carrier chemicals, DMSO

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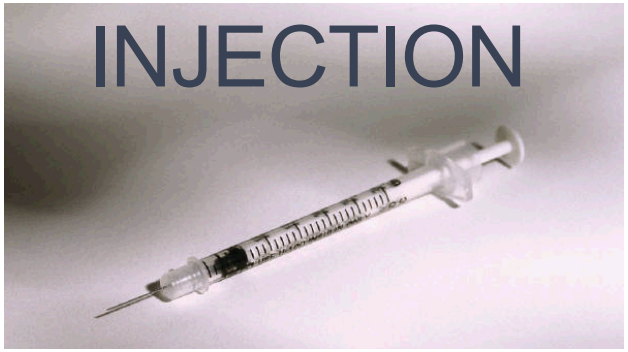


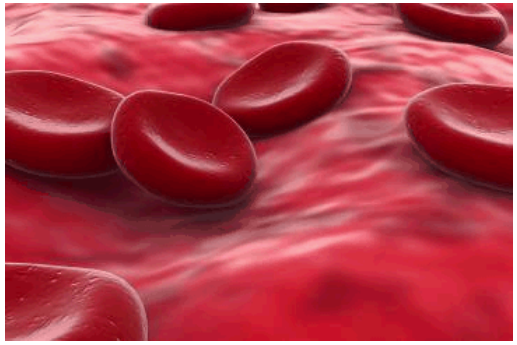
Chemical agent is introduced directly into bloodstream

"Sharps", needles, broken glass

Skin puncture or injuries

Biomedical or health care settings

- Blood borne pathogens



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EYES

Direct injury to the eye

Absorption of chemical agents through the mucous membranes around the eye

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INGESTION

Contaminated food, water, or medicine

Example: USA, 1982

- Cyanide added to Tylenol capsules
  - *Killed 7 people*
  - *Perpetrator never found*
  - *Led to tamper-proof packaging*

Example: Panama, 2006

- Diethylene glycol added to cough syrup
  - *At least 100 people killed*

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- **Blood Agents**

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CHEMICAL WEAPONS

Toxic chemicals and their precursors used for reasons other than legitimate, peaceful purposes

Munitions and devices used to disperse toxic chemicals to cause death or other harm

Gassed, John Singer Sargent, 1918.

CLASSIFICATION OF CHEMICAL WEAPONS

By organ system

- Nerve Agents
- Blister Agents (Vesicants)
- Choking Agents (Pulmonary)
- Blood Agents

Other important factors

- Lethality
- Physical and chemical properties
- Dispersal method
- Persistence in the environment
- Legitimate uses (if any)

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NERVE AGENTS

First made by Germany in 1930s

- Related to organophosphate pesticides

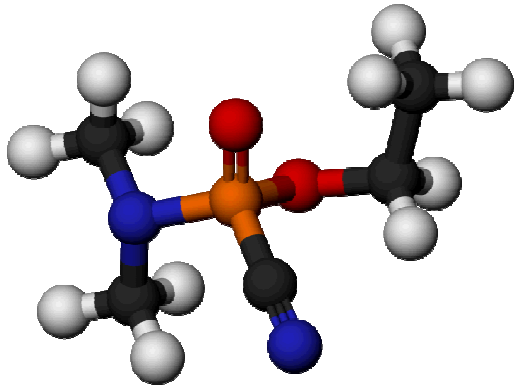
Dominant type since WWII

Inhibit the action of acetylcholinesterase

- An enzyme that breaks down the neurotransmitter acetylcholine
  - *Uncontrollable muscle contractions*

Common routes of exposure

- Inhalation
- Skin absorption



Tabun (GA)

http://en.wikipedia.org/wiki/Nerve_agent

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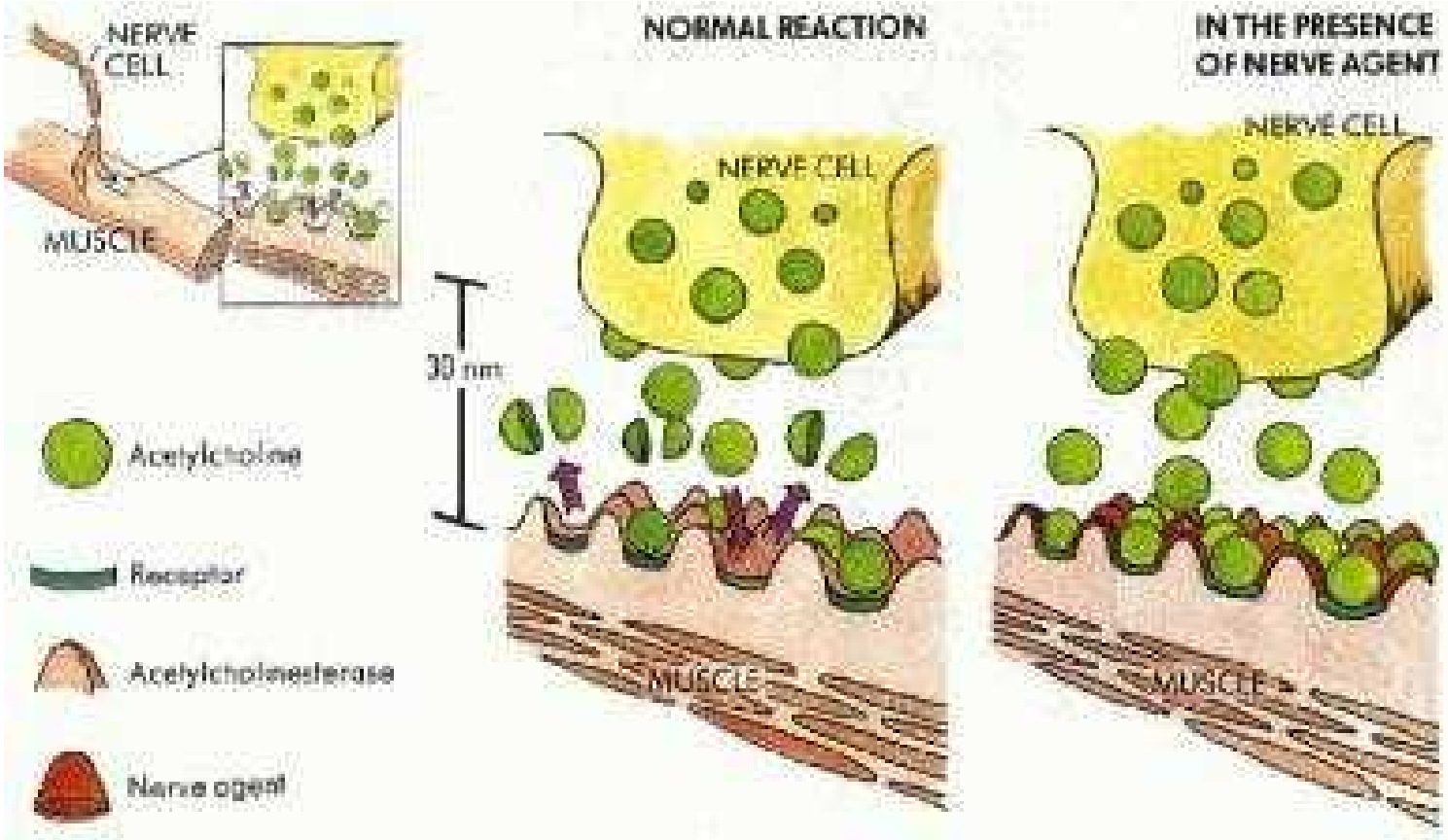
NERVE AGENTS



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NERVE AGENTS

Appearance

- Clear, colorless liquids
  - *May be viscous, oily*
- Either no odor or possibly a “fruity” odor

http://en.wikipedia.org/wiki/Chemical_weapon

Dispersal

- Modified conventional munitions
  - *Bombs, artillery shells, grenades, mines*
- Spray devices/aerosol generators
  - *Of the type used for agricultural chemicals, pesticides*

http://en.wikipedia.org/wiki/Pesticide_application

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NERVE AGENTS

Property \ Agent	Tabun (GA)	Sarin (GB)	Soman (GD)	VX
Vapor Press. (mm Hg)	0.07	2.9	0.3	0.0007
Volatility (mg/m^3)	600	17000	3900	10
Solubility in Water %	10	0	2	3*
Vapor Density	5.6	4.9	6.3	9.2

*0% at 9.5 °C

Higher vapor pressure and volatility means more inhalation hazard

Higher water solubility leads to mucosal as opposed to deep lung deposition

- Less water soluble means more toxic effect

NERVE AGENTS

Signs and symptoms (mild to severe)

- Salivation, runny nose, watery eyes, sweating, muscle cramping
- Constricted pupils, dimmed or blurred vision
- Tightness in the chest, difficulty breathing
- Loss of control of bodily functions, drooling, vomiting, diarrhea
- Convulsions, seizures, loss of consciousness
- Respiratory paralysis

http://en.wikipedia.org/wiki/Chemical_weapons

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NERVE AGENTS

Onset time

- Inhalation of vapor or aerosol
  - *Seconds to minutes*
- Exposure to liquids, skin absorption
  - *Minutes to hours*

Signs and symptoms are similar to

- Organophosphate pesticide poisoning
- Cyanide poisoning

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NERVE AGENTS

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NERVE AGENTS

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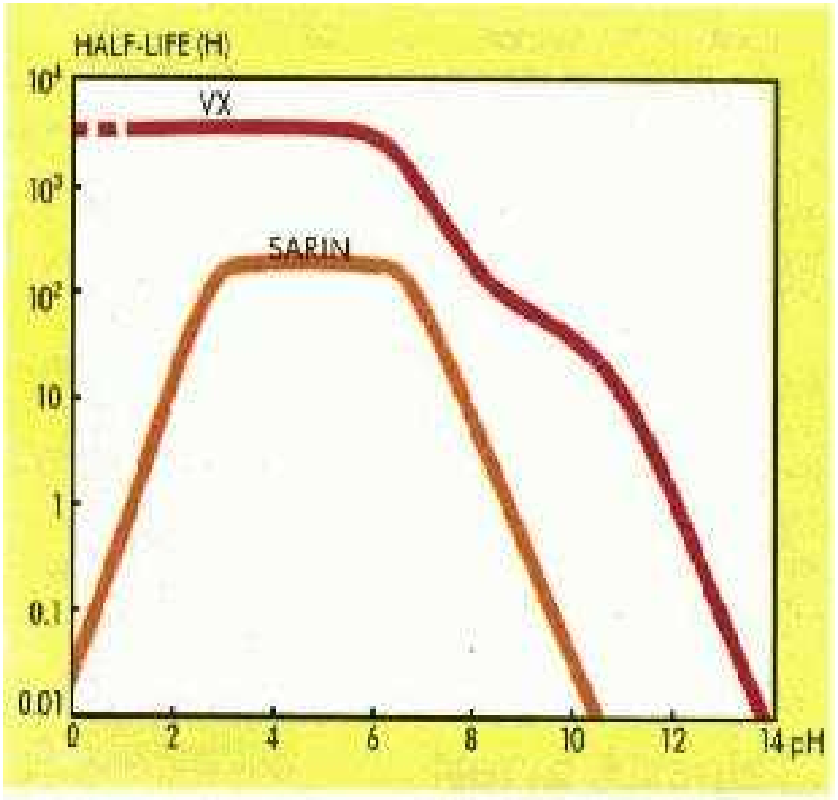
NERVE AGENTS

Decontamination

- Nerve agents decompose in water
  - *Especially in basic/alkaline solutions*
  - *Forms phosphoric acid*
    - less toxic, but corrosive
- Bleach accelerates the decomposition



Decontaminate by washing with soap and water

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NERVE AGENTS

Treatment

- Atropine
  - *Blocks acetylcholine*
- Pralidoxime chloride (2-PAMCl)
  - *Reactivates acetylcholinesterase*
  - *Works for some nerve agents*

Pre-treatment with pyridostigmine is possible

http://en.wikipedia.org/wiki/Autoinjector

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NERVE AGENTS

Route of Exposure \ Agent	Tabun (GA)	Sarin (GB)	Soman (GD)	VX
LCt_{50} (mg.min/m^3)	200	100	100	50
LD_{50} (mg/individual)	4000	1700	300	10

No legitimate uses for nerve agents, but many legitimate uses for nerve agent precursors

Be alert for:

- Groups of individuals at the same time and place showing signs and symptoms of nerve agent exposure

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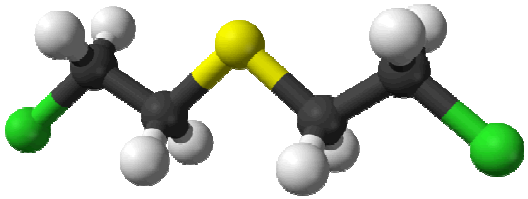
BLISTER AGENTS (VESICANTS)

Mustard agents

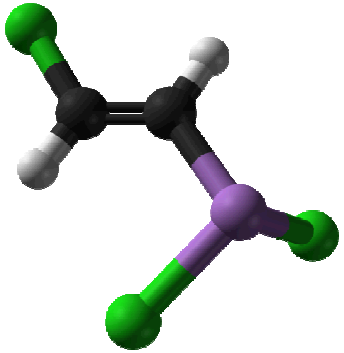
- Sulfur mustards
- Nitrogen mustards



bis(2-chloroethyl)sulfide (HD)
http://en.wikipedia.org/wiki/Sulphur_mustard

Arsenic compounds

- Lewisite
- Others



Lewisite (L)
http://en.wikipedia.org/wiki/Lewisite

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MUSTARD AGENTS

First used in WWI

Used in Iran-Iraq war in 1980s

Reacts with, alters DNA

- Prevents cell division, causes cell death
- Carcinogen

Common routes of exposure

- Skin absorption
- Inhalation
- Eyes

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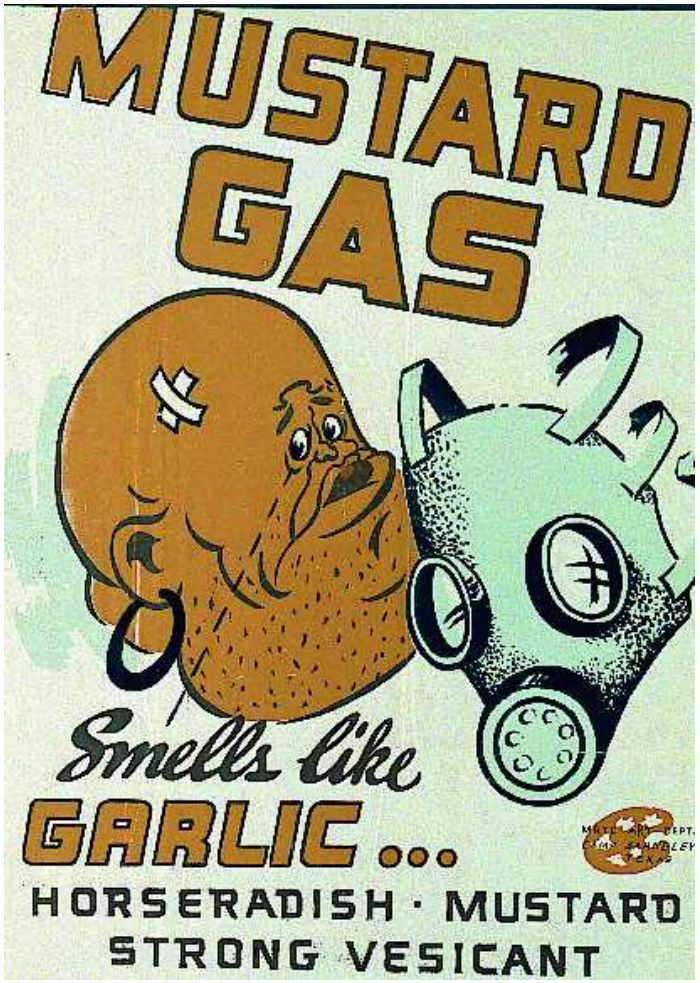

MUSTARD AGENTS

Appearance and Properties

- Pure: colorless, viscous liquid, almost odorless
- Impure: yellow-brown, smells like mustard, garlic, or horseradish
- Nitrogen mustard smells fishy
- Not soluble in water, persistent for days or weeks
    - *Vapor penetrates clothing*

Dispersal

- Modified conventional munitions
    - *Bombs, artillery shells, grenades, mines*
- Spraying as an aerosol, especially if mixed with other chemicals, organic solvents

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http://en.wikipedia.org/wiki/Sulfur_mustard

MUSTARD AGENTS

Signs and symptoms

- Itching, skin irritation
- Painful chemical burns, redness, blisters filled with yellow fluid
- Throat and lung irritation
- Bleeding and blistering within the respiratory system, pulmonary edema
- Itching, sore eyes, conjunctivitis
- Swollen eyelids, temporary blindness

Onset time

- Delayed, 2–24 hours from time of exposure

Signs and symptoms are similar to

- Chemical burns from caustics such as sodium hydroxide (NaOH) or ammonia (NH_3)

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MUSTARD AGENTS

Decontamination

- Soap and water
- Remove clothes
- Bleach decomposes mustard agents

Treatment

- Delayed effect, too late once symptoms appear
- Treat similar to thermal burn, heals slowly

http://en.wikipedia.org/wiki/Sulfur_mustard

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MUSTARD AGENTS

Route of Exposure \ Agent	Sarin	VX	**Sulfur Mustard (HD)**
LCt_{50} (mg.min/m^3)	100	50	**1500**
LD_{50} (mg/individual)	1700	10	**?**

No legitimate uses for sulfur mustard, but nitrogen mustard is used in small amounts as a cancer treatment

Mustard agent precursors are ubiquitous in industry, research laboratories, and some as commercially available chemicals

Be alert for?

- Yellow-brown viscous liquid that smells like mustard, garlic, or horseradish
- Individuals developing signs and symptoms 2–24 hours after exposure
- Unaware individuals may spread contamination

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LEWISITE

First produced in 1918 in USA

- Too late to be used in WWI
- Sometimes mixed with mustard agent
- Inferior to mustard, declared obsolete by US military in 1950s

http://en.wikipedia.org/wiki/Ww1

Contains arsenic

Interferes with enzyme important for cellular respiration

- Cell's process for producing usable energy

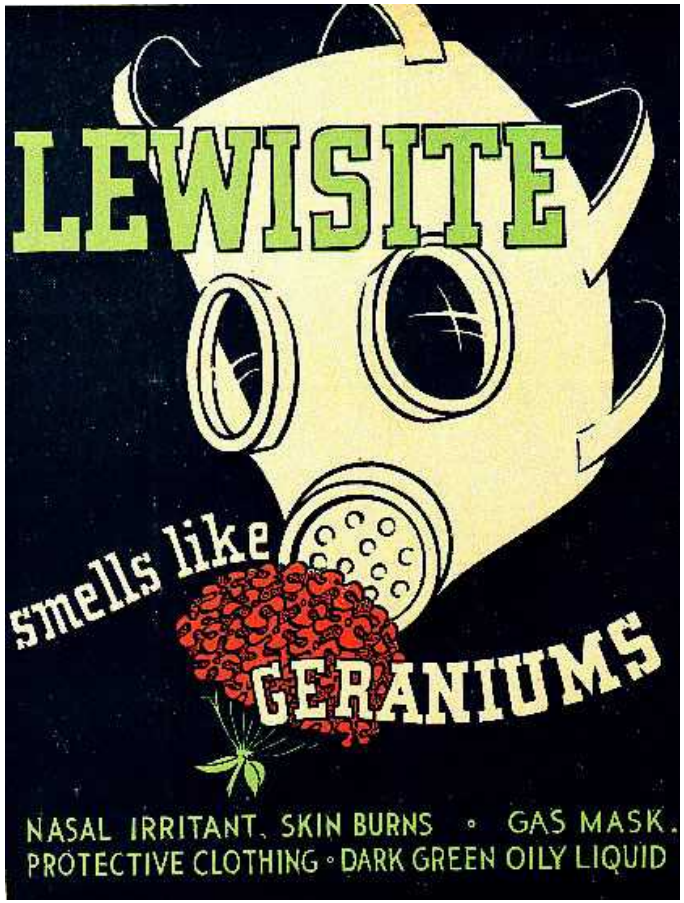
Common routes of exposure

- Inhalation
- Skin absorption
- Eyes

LEWISITE

Appearance and Properties

- Pure: oily colorless liquid
- Impure: range of colors from amber to black
- Geranium smell (flowers)
- Higher volatility than mustard agents and vapor is denser than air
- Slightly more soluble in water than mustard
- Easily penetrates clothing, can even penetrate rubber



http://en.wikipedia.org/wiki/Lewisite

Dispersal

- As a liquid from modified conventional munitions or improvised device

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LEWISITE

Signs and symptoms

- Similar to mustard agent
- Plus similar to arsenic poisoning
  - *Diarrhea, nausea, vomiting, low blood pressure*

Onset time

- Immediate or within minutes

Decontamination

- Decomposes in water, especially basic/alkaline

Treatment

- Unlike mustard, an antidote for arsenic poisoning exists
- Otherwise, treat similar to mustard

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LEWISITE

No legitimate uses for Lewisite

Lewisite is made from an arsenic precursor that may be found in some research laboratories

Be alert for?

- Oily liquid, could be amber to black in color, smells like geraniums
- Groups of individuals at the same time and place showing signs and symptoms of Lewisite exposure

http://en.wikipedia.org/wiki/Ww1

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OTHER ARSENIC COMPOUNDS

A variety of poisonous arsenic compounds exist

- Byproduct of some mining and smelting operations
- Water soluble forms: water contaminant

Effects of arsenic poisoning are immediate

- Diarrhea
- Nausea
- Vomiting
- Low blood pressure
- Edema of eyelids, face, and ankles
- Garlic odor of breath

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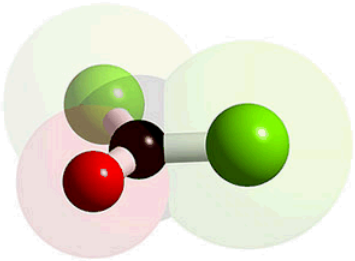
CHOKING AGENTS (PULMONARY)

Chlorine (CL)

- First used as a weapon in WWI
- Creates hydrochloric acid (HCl) in respiratory system

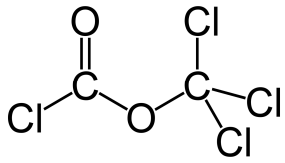
Phosgene (CG)



- First used as a weapon in WWI
- Damages proteins in the alveoli

Diphosgene

- Also used in WWI
  - *Destroyed gas mask filters*
- Creates HCl in respiratory system
- Reacts with amino acids



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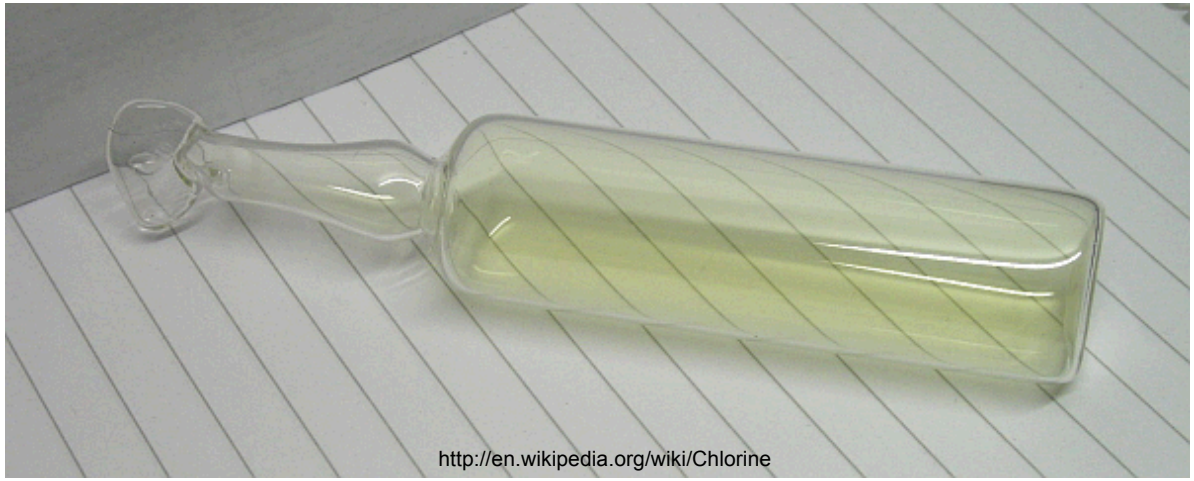
CHLORINE



Appearance and Properties

- Pale yellow-green gas
- Stored, transported as compressed gas, or sometimes as a liquid
- Pungent odor, similar to chlorine bleach
- Soluble in water, more in alkali
- More dense than air

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CHLORINE

Dispersal

- Release from compressed gas cylinders or other bulk storage tanks

USA, 2002, accidental release of about 20,000 kg of chlorine from railroad tank car

CHLORINE

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CHLORINE

Dispersal

- Coupled to an explosive device

Iraq, 2007, explosives coupled with chlorine gas

- Several attacks caused fatalities and sickened many including peaceful locals
- Pictured: truck seized by Iraqi police with 5 tons of chlorine and 2 tons of explosives

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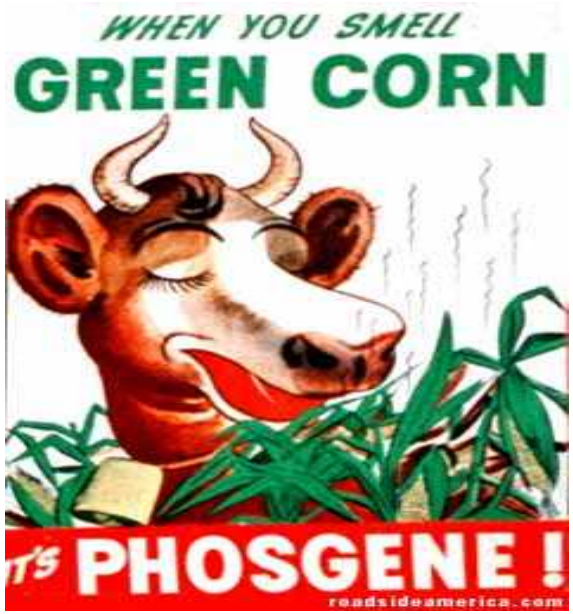
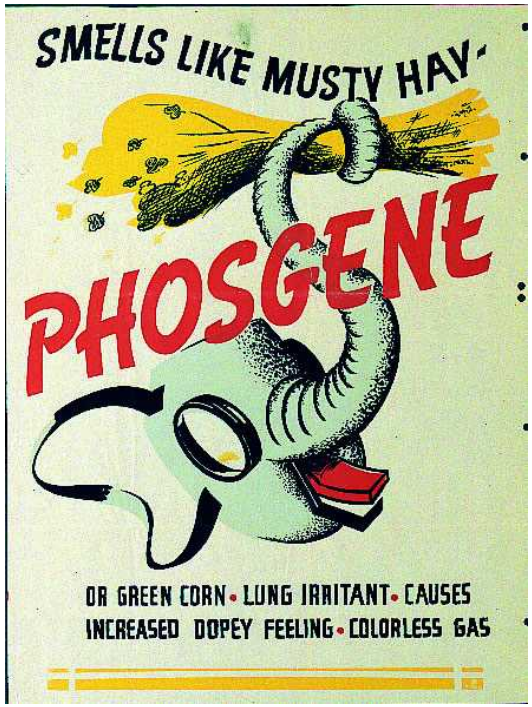
http://www.longwarjournal.org/archives/2007/03/al_qaedas_chlorine_w.php accessed Jan 2008.





PHOSGENE

Appearance and Properties

- Colorless gas, impurities may cause, white, yellow, or green color
- Odor described as green corn or moldy hay
  - *May be hard to detect*
- Denser than air

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DIPHOSGENE

Appearance and Properties

- Colorless liquid
- Not soluble in water
- High vapor pressure
- Vapor is denser than air

Dispersal

- Modified conventional or improvised munitions
- Aerosol spray

http://en.wikipedia.org/wiki/Pesticide_control

CHOKING AGENTS (PULMONARY)

Signs and symptoms

- Coughing, chest tightness
- Burning sensation in nose, throat, and eyes
- Watery eyes and blurred vision
- Nausea and vomiting
- Burning or prickling sensation on skin, irritation, redness
- Difficulty breathing, wheezing, pulmonary edema

Onset time

- Depends on concentration of exposure
  - *Immediate if concentrations are high, especially for chlorine*
  - *May be delayed if concentrations are low*
  - *Pulmonary edema and death may take 2–4 hours or more*
  - *Effects of phosgene may be delayed for up to 48 hours*

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CHOKING AGENTS (PULMONARY)

Decontamination

- Remove from affected area

Treatment

- Supplemental oxygen
- Mechanical ventilation to treat severe pulmonary edema

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CHOKING AGENTS (PULMONARY)

Route of Exposure \ Agent	Sarin (GB)	VX	Sulfur Mustard (HD)	**Chlorine (CL)**	**Phosgene (CG)**
LCt_{50} (mg.min/m^3)	100	50	1500	**6000**	**3000**

Chlorine

- Water purification, oil industry, semi-conductor industry
- Over 11 billion kilograms produced in 1995

Phosgene and diphosgene

- Dyes, plastics, pesticides, pharmaceuticals
- Billions of kilograms produced annually

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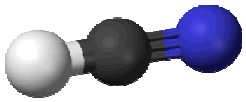
Be alert for?

- Yellowish heavier-than-air gases with characteristic odors
- Affected individuals developing immediate respiratory distress (chlorine)
- Affected individuals with delayed respiratory distress (phosgene)

BLOOD AGENTS

Hydrogen cyanide (AC)

- First used as a weapon in WWI
- Occurs naturally in some plants
- Contained in smoke from some plastics, other materials



http://en.wikipedia.org/wiki/Hydrogen_cyanide

Cyanogen chloride

- Use as a weapon has been considered

http://en.wikipedia.org/wiki/Cyanogen_chloride

Prevent cells from using oxygen

Common routes of exposure

- Inhalation
- Eyes
- Skin absorption

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BLOOD AGENTS - CYANIDES

Hydrogen Cyanide

- Highly volatile pale blue liquid, colorless gas
- Less dense than air
- Dissolves in water
- Smells like bitter almond
  - *Not all people can smell it*
- Not an irritant upon exposure

Cyanogen chloride

- Colorless gas
  - *Colorless liquid at colder temperatures (~13 °C)*
- More dense than air
- Dissolves in water
- Pungent smell
- Irritates the eyes, nose, and throat upon exposure

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Dispersal

- Released as a gas, aerosol, or used to contaminate food or water

BLOOD AGENTS - CYANIDES

Signs and symptoms

- Anxiety, dizziness, restlessness
- Hyperventilation
- Headache, weakness
- Nausea, vomiting
- “Cherry red” skin, rapid heart rate
- Convulsions, loss of consciousness
- Respiratory failure

Onset time

- Seconds to minutes

Signs and symptoms are similar to

- CO or H_2S exposure
- Nerve agents

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BLOOD AGENTS - CYANIDES

Decontamination

- Remove from affected area
- Remove contaminated clothing
- Wash with soap and water

Treatment

- Supplemental oxygen
- Cyanide antidotes

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BLOOD AGENTS - CYANIDES

Route of Exposure \ Agent	Sarin (GB)	VX	Sulfur Mustard (HD)	Chlorine (CL)	Phosgene (CG)	**Hydrogen Cyanide (AC)**
Inhalation LCt_{50} ($mg.min/m^3$)	100	50	1500	6000	3000	**2500**

Cyanides are important to many industries

- Electroplating, mining, polymers

Be alert for?

- Colorless gases with characteristic odors
- Groups of individuals, especially indoors, developing immediate signs and symptoms

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Code	Agent	Volatility (mg/m^3)	Vapor Density (air = 1.0)	Solubility in Water %	LCt_{50} ($mg.min/m^3$)	LD_{50} (mg/kg)
AC	Hydrogen cyanide	1000000	0.94			
CG	Phosgene	(gas)	3.5			-
CL	Chlorine	(gas)	2.5			-
HD	Sulfur mustard	610	5.4		1500	?
L	Lewisite	4480	7.1			
GB	Sarin	17000	4.9	0	100	1700
GD	Soman	3900	6.3	2	100	300
GA	Tabun	600	5.6	10	200	4000
VX	VX	10	9.2	3	50	10

EXERCISE – CHEMICAL AGENTS COMPARISON

Using the previous table

1. Identify the most toxic agent

2. Identify the agent with a vapor density most like that of air

3. What agent is likely to be the most persistent in the environment and why?

4. What factors are the most important for determining an appropriate response and why?

OVERVIEW

Principles of Toxicity

Absorption of Chemical Agents

- Chemical and Physical Properties
- Routes of Exposure

Chemical Weapons

- Nerve Agents
- Blister Agents (Vesicants)
- Choking Agents (Pulmonary)
- Blood Agents

Other Chemical Agents

- **Riot Control Agents**
- **Dual-Use Chemicals**
  - ***Toxic Industrial Chemicals/Materials (TICs, TIMs)***
  - ***CW Precursors and other illicit use***

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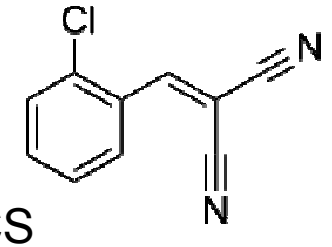
RIOT CONTROL AGENTS

Tear gas

- Many types, CS has become the most common

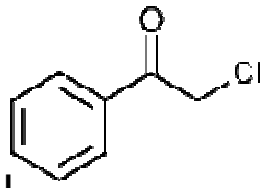


CS

http://en.wikipedia.org/wiki/CS_gas

Mace

- A brand of tear gas, originally CN, now usually OC or mixtures



CN

http://en.wikipedia.org/wiki/CN_ga

Pepper Spray

- Oleoresin Capsicum, OC, derived from chili peppers

http://en.wikipedia.org/wiki/Capsicum

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RIOT CONTROL AGENTS

Tear gas

- White solid at room temperature
- Aerosolized for use, appears as a white smoke

Signs and Symptoms

- Irritation and pain in eyes, nose, mouth, throat, and lungs
- Watery eyes, blurred vision
- Difficulty breathing
- Nausea, skin irritation

Onset time is from seconds to minutes

Effects usually subside in 30–60 minutes

http://en.wikipedia.org/wiki/CS_gas

RIOT CONTROL AGENTS

Pepper Spray

- Used as a liquid solution or aerosol
- Effects are similar to tear gas

http://en.wikipedia.org/wiki/Pepper_spray

http://en.wikipedia.org/wiki/CS_gas

Decontamination and Treatment

- Rinse eyes
- Wash with soap and water

Some terrorist attacks have involved riot control agents

DUAL-USE CHEMICALS

Toxic Industrial Chemicals/Materials (TICs/TIMs)

- Theft, diversion
  - *Steal large quantities of TICs for use as a weapon elsewhere*
- Sabotage
  - *Cause an intentional release, especially near a populated area*

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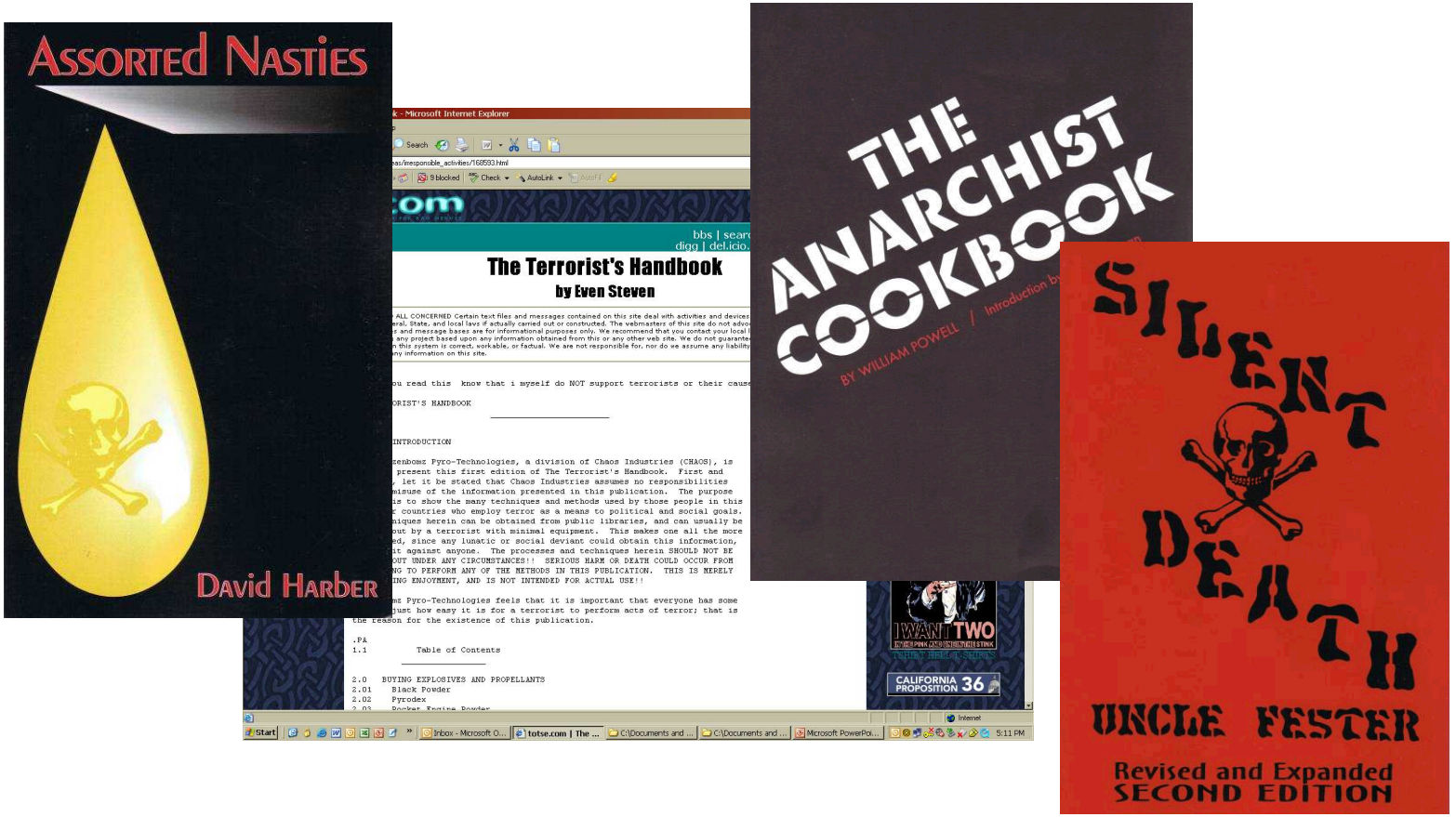
DUAL-USE CHEMICALS

High Hazard TIC	Example Industries
Ammonia	Est. annual global production is nearly 200 million tonnes for use in agriculture, pharmaceuticals, cleaning products, etc.
Boron trichloride	Metal refining, electronics, chemical production
Carbon disulfide	Insecticide/fumigation, solvent, polymers, electronics
Ethylene oxide	Est. annual global production is over 20 million tonnes for use in chemicals production, antifreeze, lubricants, plastics
Hydrogen fluoride	Oil refining, polymers, pharmaceuticals
Formaldehyde	Est. annual global production is over 10 million tonnes for use in polymers, resin, foam, adhesive, paint, preservative
Sulfuric acid	Est. annual global production is nearly 200 million tonnes for use in fertilizer manufacturing, detergents, resins, pigments, pharmaceuticals, oil refining, batteries, cleaners

DUAL-USE CHEMICALS

Long history of people misusing chemicals

Information on how to use chemicals maliciously is easy to get



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DUAL-USE CHEMICALS

A large number of common chemicals can be used for malicious purposes

- Weapons precursors
- Drugs
- Explosives

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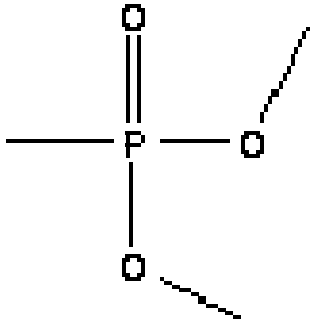
DUAL-USE CHEMICALS

CW Precursor Examples

Dimethyl methyl phosphonate (DMMP)

- Flame retardant
- Nerve agent precursor



Thiodiglycol

- Dyes/inks, cosmetics, pharmaceuticals, polymers, coatings, etc.
- Mustard agent precursor

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DUAL-USE CHEMICALS

Pseudoephedrine

Legitimate use

A common ingredient in cold medicines

Misuse

Synthesis precursor to crystal methamphetamine

USA, 2002, clandestine meth labs

- Caused 194 fires, 117 explosions, and 22 deaths
- Cost $23.8 million for cleanup
- Dumped chemicals harm environment

Processing illegal drugs requires a variety of chemicals

- Global terrorism can be funded by illegal drug activity

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US DEA, http://www.deadiversion.usdoj.gov/pubs/brochures/pseudo/pseudo_trifold.htm, accessed Dec 2007.

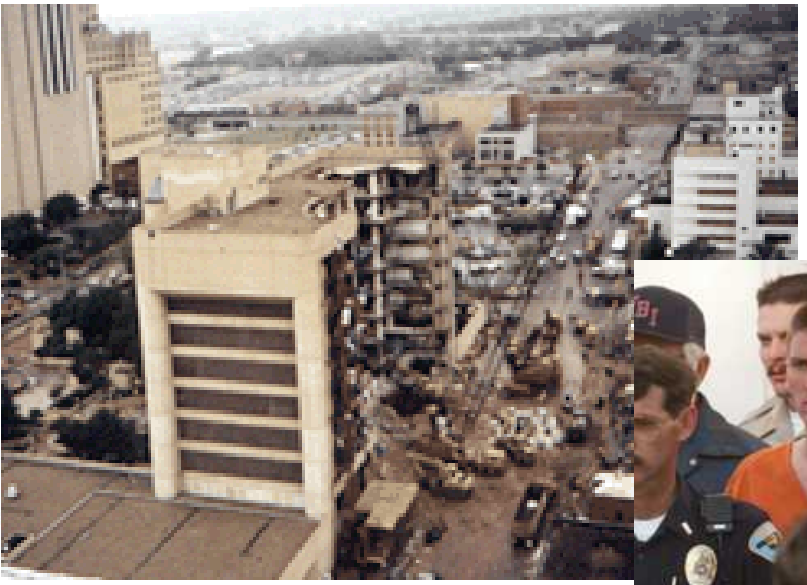
DUAL-USE CHEMICALS

Ammonium Nitrate

Legitimate use

Agriculture

ANFO ingredient (industrial explosive)



Misuse

ANFO ingredient (used maliciously)

USA, 1995, bombing of federal building in Oklahoma City

- 168 killed, including 19 children, and almost 700 injured
- Timothy McVeigh, an antigovernment extremist

Also used by other groups around the world

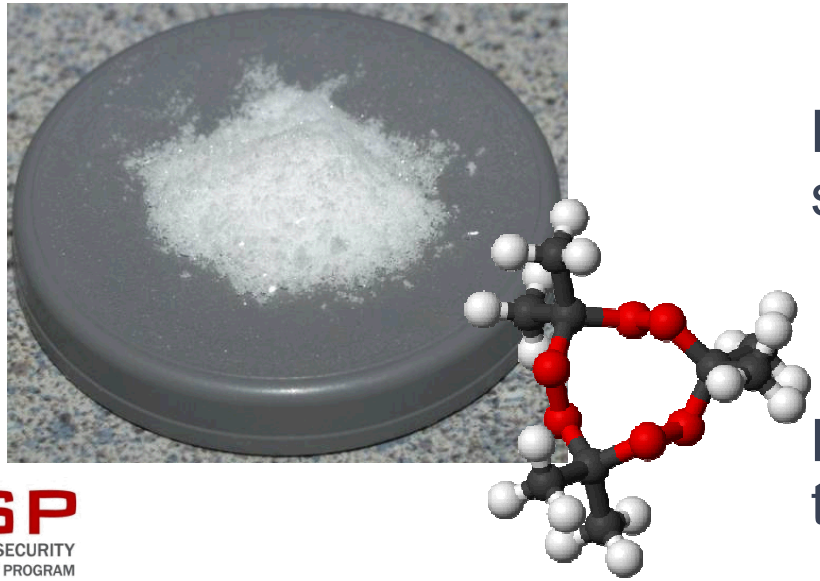
http://www.fbi.gov/about-us/history/famous-cases/oklahoma-city-bombing

DUAL-USE CHEMICALS

Acetone, Hydrogen Peroxide, and Acid

Legitimate uses

Too numerous to list



Misuse

Precursors to TATP

London, 2005, bus and subway suicide bombings

- 52 killed, over 770 injured

Multiple other bomb plots around the world

- Invisible to detectors for nitrogen-based explosives

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http://en.wikipedia.org/wiki/Acetone_peroxide

DUAL-USE CHEMICALS

Chicago, USA, 2002

- Joseph Konopka arrested in tunnels under the University of Illinois
- Had NaCN on him and a stockpile of stolen chemicals including NaCN and KCN in subway
- Sentenced to 13 years in prison for “possessing a chemical weapon” and other charges

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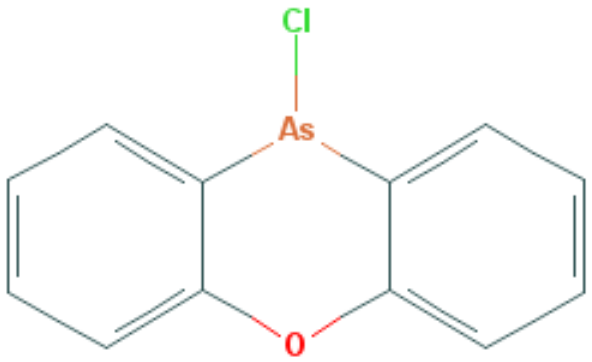
http://articles.cnn.com/2002-03-12/us/chicago.cyanide_1_cyanide-in-chicago-subway-sodium-cyanide-chicago-police?_s=PM:US
http://articles.chicagotribune.com/2004-01-04/features/0401040453_1_tunnels-urban-exploration-city-hall

DUAL-USE CHEMICALS

Philadelphia, USA, 2007

- A microbiologist stole 10-chlorophenoxyarsine from work
- Attempted to poison her husband's lover



Hazardous chemicals are used to harm others too often

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http://articles.cnn.com/2011-06-16/justice/us.scotus.poisoned.paramour_1_potassium-dichromate-myrlinda-haynes-carol-anne-bond?_s=PM:CRIME
http://www.chemindustry.com/chemicals/0437452.html

SUMMARY

Principles of Toxicity

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- Chemical and Physical Properties
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- Blister Agents (Vesicants)
- Choking Agents (Pulmonary)
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CONCLUSIONS

Toxicity depends on dose and other factors

Military chemical weapons are categorized according to organ system

Many Toxic Industrial Chemicals or other common chemicals could be used as weapons or to make weapons

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