CHAPTER II

CLASSIFICATION AND EFFECTS

- Chemical Warfare Agents.

- Biological Warfare Agents.
CHEMICAL WARFARE AGENTS

Modern life depends on the use of chemicals. In our century great progress has been made in chemical industry, Science and medicine. Of more than 6 million known chemicals there are now 60 to 70 thousand in common use. Between 500-1000 new chemicals come on to the market each year.¹ Many of these chemicals are hazardous by their nature and great care must be taken when using them, storing them and disposing of them. Special problems arise when chemicals which have never before appeared in nature, such as chemical warfare agents, are produced in large quantities. Military research centres and other research institutions in many countries are working intensively on discovering new agents and on improving chemical weapons.

By chemical weapons, we mean those chemical agents which are based on the toxic properties of chemicals rather than on the energetics of, their interaction.

Chemical agents are inorganic substances used in warfare to attack the organs of the human body in such a way that they prevent those organs from functioning normally. The intention is either to prevent the human body from functioning at all or to somehow prevent some aspect or another of its normal processes from proceeding
normally. The results are usually disabling to a varying degree or fatal.

The chemical agents applied in war which, by ordinary and direct chemical action, produce a toxic or powerful irritant effect on human body. Solids, liquids, or true gases, may be applied as chemical warfare agents however, in their actual use in the battle area, the solid or liquid is converted by normal or artificial volatilization into a true gas or is disseminated as minute solid or liquid particles called aerosols. Irritant smokes are types of aerosols included under the term gas because their principal use is for their physiological effect.

On the basis of (i) Purpose, and (ii) Degree of toxicity, the chemical warfare agents can be classified into two following groups:

(i) **Single purpose agents:**

Chemicals that can be used for military purposes and which do not currently possess civilian significance eg. V-Compounds (VX), Soman (GD), Sarin, Tabun (GA), S-Mustard (HD), N-Mustard (HM) etc.

Estimated toxicity values of some single-purpose agents are given below:-
<table>
<thead>
<tr>
<th>NAME</th>
<th>$LD_{50}$</th>
<th>$LC_{50}$</th>
<th>EXPOSURE LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(MG/MAN)</td>
<td>(MG/MIN/M^3)</td>
<td>(MG/M^3)</td>
</tr>
<tr>
<td>V-Compounds (VX)</td>
<td>7-14</td>
<td>10-50</td>
<td>0.00001</td>
</tr>
<tr>
<td>Soman (GD)</td>
<td>700-1400</td>
<td>50-100</td>
<td>-</td>
</tr>
<tr>
<td>Sarin (GS)</td>
<td>1750-3500</td>
<td>100</td>
<td>0.0001</td>
</tr>
<tr>
<td>Tabun (GA)</td>
<td>3500-4900</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
<td>S-Mustard (HD)</td>
<td>2800-4200</td>
<td>1500</td>
<td>0.003</td>
</tr>
<tr>
<td>N-Mustard (HM)</td>
<td>700-1400</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(ii) Dual purpose agents:

Which can be used both for military and peaceful purposes eg. Phosgene, Hydrogen Cyanide, Cyanogen Chloride, Chlorine etc.

**TOXICITY VALUES OF SOME DUAL-PURPOSE AGENTS**

<table>
<thead>
<tr>
<th>NAME</th>
<th>$LC_{50}$</th>
<th>EXPOSURE LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(MG MIN/M^3)</td>
<td>(PPM MG/M^3)</td>
</tr>
<tr>
<td>Phosgene</td>
<td>3200-3500</td>
<td>0.1 0.4</td>
</tr>
<tr>
<td>Hydrogen Cyanide</td>
<td>2000-4500</td>
<td>10 11</td>
</tr>
<tr>
<td>Cyanogen Chloride</td>
<td>7000-11000</td>
<td>-</td>
</tr>
<tr>
<td>Chlorine</td>
<td>19000</td>
<td>1.0 3.0</td>
</tr>
</tbody>
</table>
From the military point of view the most important classification of chemical warfare agents are in accordance with:

i. Physiological effect.

ii. Persistency.

iii. Tactical use.

The Physiological effect classifies the chemical according to its primary action on the human body even though it may produce other secondary effects. The severity of effect is roughly proportional to the concentration and the time of exposure. Further the classification of chemical warfare agents has been proposed as following:

i. Chocking Agents.

ii. Blister Agents.

iii. Blood Agents.


v. Vomiting Agents.

vi. Tear Agents.

vii. Incapacitating Agents.

The following description of chemical warfare agents should not be taken as complete. It contains most of the known military chemical agents but new horrors are constantly being devised in laboratories all around the world and are
cell walls heal, and the patient recovers. However respiratory problems of one form or another may remain chronic for years. The severity of poisoning can not be estimated from the immediate symptoms, since the full effect is not usually apparent until 3 or 4 hours after exposure. It is a delayed casualty agent.

Diphosgene\(^6\), chemical name Trichloromethyl Chloroformate, as a shell filling, it has the advantage of a high boiling point which permits filling in the field. However, Diphosgene does have certain disadvantages. Since it is slightly lacrymatory, troops are not as easily surprised as with phosgene. It is converted to phosgene in the body and exerts its effect after this conversion. Since Diphosgene is converted, the physiological action is the same for both the agents.

Chlorine\(^7\) is now of little use and is rarely encountered in a military context. Rate of hydrolysis-slow, odour-pungent and unmistakable, Like bleaching powder. It is powerful irritant, first on upper and then on lower respiratory tract. Duration of effectiveness is shorter.

ii. BLISTER AGENTS:--

These are used for casualty effect, the use of ground may be restricted, movements slowed, and use of
material or installation hampered. They attack any part of
the body with which the liquid or vapour comes in contact,
especially moistened parts. They are absorbed or dissolved
on exterior or interior parts of the body, followed by
production of inflammation, burns and destruction of tissue.
There is no immediate pain and effect is delayed for some
period after exposure. Protection against this class of
agents is very difficult because of their insidious action.
These agents affect the eyes and lungs and blister the skin.
Now many blister agents have been developed which are
odourless and vary in duration of effectiveness. The
important agents of this class are Mustard gas, Lewisite,
Phenyldichloroarsine, Methyl dichloroarsine and
Ethyl dichloroarsine etc.

Distilled Mustard (HD)\(^9\), chemical name-2,2',
dichlorodiethyl Sulfide, it is purified by washing and
vacuum distillation and odour like Garlic. Mustard acts
first as a cell irritant and finally as a cell poison on
all tissue surface contacted. Delayed rate of action
usually 4 to 6 hours or more have been observed. The
physiological action of Distilled Mustard may be classified
as local and general. The local action results in conjuncti-
vitis or inflammation of the eyes, erythema which may be
followed by blistering or ulceration, and inflammation of
the nose, throat, trachea, bronchi, and lung tissue.

The Nitrogen Mustards are a group of related compounds which may be considered as derivatives of amonia because the hydrogen atoms are replaced by various organic radicals. In each of these chemical agents, Nitrogen is the central atom. A few important agents of this group are Nitrogen Mustard HN-1, HN-2 and HN-3, odour-faintly fishy or musty, delayed rate of action 12 hours or longer. Eyes are susceptible to low concentration, higher concentrations are required to produce incapacitating effects by skin absorption rather than by eye injury, effects on the respiratory tract include irritation of the nose and throat, hoarseness progressing to loss of voice, and a persistent cough. Fever, laboured respiration, and moist rates may develop. Broncho-pneumonia may appear after the first 24 hours. Ingestion or systematic absorption, causes injury to intestinal tract. Duration of effectiveness depends on the munitions used and weather.

Mustard- T Mixture (HT) is a mixture of 60 percent distilled mustard and 40 percent T.T., a sulphur and chlorine compounds. It causes blisters, irritates eyes and is toxic when inhaled. It has a longer duration of effectiveness, is more stable, and has a lower freezing point than distilled mustard.
Phosgene Oxime (CX)\textsuperscript{10} Dichloroformoxime is a colourless, low melting point solid or as a liquid. It is a powerful irritant which produces immediate pain and violent irritation to the mucous membrane of the eyes and nose. When it comes in contact with the skin, the area becomes blanched and is surrounded by a red ring.

Lewisite (L), chemical name- Dichloroarsine, odour like Geranium, effect similar to distilled mustard but, in addition, acts as a systemic poison, causing pulmonary oedema, diarrhoea, restlessness, weakness, subnormal temperature and low blood pressure. When inhaled in high concentrations it may be fatal in as short a time as ten minutes. Duration of effectiveness is very short under humid conditions.

Mustard-Lewisite Mixture (HL) is a variable mixture of Lewisite (63\%) and distilled Mustard. It causes severe damage to the eyes. Contamination of the skin is followed after a short time by reddening, then by blistering which tends to cover the entire area of the reddened skin. In the most severe cases pulmonary oedema may be accompanied by pleural effusion. Duration of effectiveness depends on the munitions used and weather.

Phenyldichloroarsine (PD) is classed here as a blister agent, it also acts as vomiting agent. Rate of
action immediate affects eyes but on skin delayed from 30 minutes to an hour. It is less effective than distilled mustard.

Ethyl dichloroarsine (ED)\textsuperscript{11} was introduced by the Germans in March 1918. Odour - fruity, but biting and irritating. Its vapour is irritating but not harmful to eyes and skin except on prolonged exposure. Liquid ED has approximately one twentieth the blistering action of liquid Lewisite.

Methyldichloroarsine (MD), as with lewisite and other similar arsenicals, MD is irritating to the respiratory tract and produces lung injury upon sufficient exposure. The vapour is irritating to the eyes and the liquid may produce severe eye injury. The absorption of either vapour or liquid through skin in sufficient amounts may lead to systemic poisoning or death. Duration of effectiveness is relatively short.

iii. **BLOOD AGENTS**\textsuperscript{12}:

Blood agents directly affect the heart action or nerve reflexes, or interfere with absorption and assimilation of oxygen by the body. The agents are absorbed into the body primarily by breathing. They affect bodily functions through action on the enzyme Cytochrome-oxidase,
thus preventing the normal transfer of oxygen from the blood to body tissue.

Carbon Monoxide and Hydrocyanic acid, which pertain to this class, have never been effectively used in war because they are lighter than air and do not remain for long on a given ground area. Except these, a few important examples of this group are Cyanogen Chloride, Arsine etc.

Hydrogen Cyanide (HCN) or Hydrocyanic acid\(^{13}\) is a paralysant that acts on the central nervous system to produce quick death. It has a slight odour, resembling that of bitter almonds. However, its usefulness is limited, principally due to the rapid dissepation of the agent in the field because of its high volatility. Some what better success in building up effective field concentrations may be obtained by delivering the agent to the target in gas bombs of large volume, when this is done, a phenomenon of cloud cooling occurs, permitting a nonpersistent gas cloud to remain in the target area for several minutes.

An other well known blood agent is cyanogen chloride (CK)\(^{14}\). Its rate of hydrolysis is very slow. Its irritating and lacrimary properties are so great that the odour can go unnoticed. Too low to be of military importance in connection with the skin and eye toxicity. The general
action of Cyanogen Chloride is similar to that of hydrogen cyanide. It interferes with the utilisation of oxygen by the body tissues. However, it differs from hydrogen cyanide in that it has a choking effect, a strong irritating effect, and causes a slow breathing rate.

Arsine (SA), chemical name- Arsenic trihydride, odour like mild garlic, rate of hydrolysis is rapid, but an equilibrium condition is reached quickly. Under certain conditions arsine forms a solid product with water which decomposes at 30°C. Arsine interferes with functioning of the blood, and damages the liver and kidneys. Slight exposure causes headache and uneasiness. Increased exposure causes hills, nausea and vomiting. Severe exposure damages blood, causing anaemia. Duration of effectiveness is short.

iv. NERVE AGENTS:

While the nerve agents differ in molecular structure, they have the same physiological action on man in that they upset the balance between sympathetic and parasympathetic nervous system which together are the autonomic nervous system. Nerve agents inhibit the normal action of the body enzyme, cholinesterase, thereby causing an accumulation of toxic amounts of acetylcholine. This leads to continual stimulation of the parasympathetic nerve
system. The vapours, when inhaled, may cause nausea, vomiting and diarrhea, these effects may be followed by muscular twitching and convulsions. Even in low concentrations the vapours cause eye pupils to contract; Vision becomes difficult and headache may result. After short exposure a sense of tightness in the chest may be noticed. Small amounts of liquid nerve gas on the skin may cause salivation and a twitching of affected area. Severe cases of nerve gas poisoning rapidly result in convulsions, coma and unless promptly treated death. The most important examples are Tabun, Sarin, Soman and V-agents.

Tabun (GA), chemical name- Dimethylaminoethoxycyanophosphinme oxide, odour-faintly fruity non when pure, is colourless to brownish liquid giving colourless vapour.

Sarin (GB), chemical name-Methylisopropoxy-fluro-phos-phine oxide, almost no odour in pure state, very rapidly hydrolysed in alkaline solutions.

Soman(GD), chemical name-Methylpinacolyloxy-fluoro-phosphine oxide, fruity odour, with impurities, odour of camphor.

Eye and skin toxicity.
(a) Eye effect:—Very high toxicity, vapour causes pupil of eye to contract, resulting in difficulty in seeing in dim light and generally distorted vision.

(b) Skin effect:—Extremely toxic by skin absorption. Liquid does not injure the skin but penetrates it rapidly.

Individuals poisoned by these agents (GA, GB, GD) display approximately the same sequence of symptoms regardless of the route by which the poison enters the body by inhalation, absorption or ingestion. These symptoms in normal order of appearance, are running nose, tightness of chest, dimness of vision and pinpointing of the eye pupils, difficulty in breathing, drooling and excessive sweating, nausea, vomiting, cramps and involuntary defaecation and urination, twitching, jerking and staggering, and headache, confusion, drowsiness, coma and convulsion. Symptoms appear much more slowly from skin dosage than from respiratory dosages. Although skin absorption great enough to cause death may occur in 1 to 2 minutes, death may be delayed for 1 to 2 hours. Respiratory lethal dosages kill in 1 to 10 minutes, and liquid in the eye kills nearly as rapidly. Duration of effectiveness depends upon the munitions used and the weather.
V-agents, included in the category of nerve agents are VE, VM, VS and VX. The standard V-agent is VX, its chemical name is (0-ethyl S-(2-disopropylamino ethyl)methyl phosphonothiolate). Unlike sarin, VX is non volatile and highly persistent, normally appears as a heavy oil liquid. It is more toxic than either sarin or soman and about half miligram can be fatal when inhaled. VX may persist for weeks in cold climate but only a few days in warmer ones. The other V-agents Chemical names are :-

VE - O-ethyl S-(2-diethylaminoethyl) ethylphosphonothiolate.
VM - O-ethyl S-(2-diethylaminoethyl) methylphosphonothiolate.
VS - O-ethyl S-(2-diisopropylaminoethyl)ethylphosphonothiolate.

V-agents are generally colourless and odourless liquids which do not evaporate rapidly. They are absorbed by vegetation. In liquid or aerosol form, these agents affect the body in a manner similar to that of nerve agents. They are usually disseminated as liquid droplets which produce casualties when absorbed through the skin. Since liquid nerve agents evaporate quickly from the skin, the dosage required to produce casualties by that route is high and the time to appearance of casualties is correspondingly short as compared with the much less volatile V-agents. If evaporation is excluded, the time to appearance of casualties would be roughly similar at the same dose level.
with both V-agents and nerve agents.

v. VOMITING AGENTS\textsuperscript{17}:

The most of the vomiting agents are normally solids which, when heated, vapourise and then condense to form toxic aerosols. Under field conditions, vomiting agents cause great discomfort to their victims; when released indoors, they may cause serious illness or death. They are primarily used for mob and riot control. The three principal vomiting agents are discussed below.

Diphenylchloroarsine (DA) is an important vomiting agent. Its rate of hydrolysis slow in mass but rapid when finally divided. No pronounced odour, and rate of action is very rapid. In progressive order, irritation of the eyes and mucous membranes. Viscous discharge from the nose similar to that caused by a cold, sneezing and coughing, severe headache, acute pain and tightness in the chest, and nausea and vomiting. For moderate concentrations the effects last about 30 minutes after an individual leaves the contaminated atmosphere. At higher concentrations, the effects may last up to several hours. Duration of effectiveness is short because agent is disseminated as an aerosol.

Adamsite (DM)\textsuperscript{18}, chemical name-Diphenylaminochloroarsine. Rate of action is very high, no pronounced
odour. Its effects are same as with DA, but the effects develop more slowly. At higher concentrations, the effects may last upto 3 hours.

Diphenylcyanoarsine (DC), odour, similar to a mixture of garlic and bitter almonds. Rate of action is very rapid. Higher concentrations are intolerable in about 30 seconds. It is more toxic than DA. Rest effects are similar to DA and DM.

vi. TEAR AGENTS\(^{19}\):

They irritate the mucous membrane around the eyes, causing intense smarting and a profuse flow of tears with resultant hampering of vision. Effect from concentrations in the field is only temporary, recovery being complete with in a few minutes after removal from contaminated area. They have little more than nuisance value in war in view of the effectiveness of the modern protective respirator. The principal tear agents are discussed below.

Chloroacetophenone (CN), not readily hydrolised, odour-fragrant, similar to apple blossoms. In addition to powerful lacrimary effects, it is an irritant to the upper respiratory passages. In higher concentrations, it is irritating to the skin and causes a burning and itching sensation, especially on moist parts of the body.
and may also cause blisters.

CNC, is the solution of chloroacetophenone in chloroform. So its odour is similar to chloroform. It causes flow of tears, irritates respiratory system and cause stinging to skin.

CNS like CNC, has no chemical name. It is a mixture of chloroacetophenone, chloropicrin and chloroform, odour-like flypaper. In addition to having effects described under chloroacetophenone, it also has the effects of chloropicrin (PS) which acts as vomiting agent, a choking and a tear agent. It may cause lung effects similar to those of phosgene and may also cause nausea, Vomiting, Colic and diarrhoea which may persist for weeks.

CNB, is the solution of chloroacetophenone in benzene and carbon tetrachloride. Odour-like benzene and duration of effectiveness is short. It was adopted in 1920 and remained in use until it was replaced by CNS.

BBC, Bromobenzylcyanide produces a burning sensation of the mucous membranes severe irritation and lacrimation of the eyes with acute pain in the forehead. It is less toxin than phosgene. Odour-like soured fruit and duration of effectiveness depends upon the weather and the munitions used. Heavily splashed liquid persists 1 to
2 days under average weather conditions.

**CS.0 - Chlorobenzalmononitrile,** is a white crystalline powder which is insoluble in water but soluble in methylene chloride. Odour—pepper like, and produces immediate effects even in low concentrations. The onset of incapacitation is 20 to 60 seconds and the duration of effects is 5 to 10 minutes after the affected individual is removed to fresh air. The physiological effects include extreme burning of the eyes accompanied by copious flow of tears, coughing, difficulty in breathing, and chest tightness, involuntary closing of the eyes, stinging sensation of moist skin, running nose, dizziness or swimming of the head. Heavy concentrations will cause nausea and vomiting in addition to the above effects.

There are at least a dozen representatives of Tear Agents:

<table>
<thead>
<tr>
<th>Lacrimators</th>
<th>Minimum concentration (ml.gm/litre)</th>
<th>Volatility at the temp. lethal 20°C (ml.gm/litre)</th>
<th>Minimum concentration (ml.gm/litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bromobenzyl Cyanide</td>
<td>0.00015</td>
<td>0.1300</td>
<td>0.35</td>
</tr>
<tr>
<td>2. Chloroacetophenone</td>
<td>0.0030</td>
<td>0.1060</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
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<td>----------</td>
</tr>
<tr>
<td>3. Ethyldioacetate</td>
<td>0.0014</td>
<td>3.1000</td>
<td>1.50</td>
</tr>
<tr>
<td>4. Bromoacetone</td>
<td>0.0015</td>
<td>75.0000</td>
<td>3.20</td>
</tr>
<tr>
<td>5. Chloropicrin</td>
<td>0.0020</td>
<td>165.0000</td>
<td>2.00</td>
</tr>
<tr>
<td>6. Benziliodide</td>
<td>0.0020</td>
<td>0.0012</td>
<td>3.00</td>
</tr>
<tr>
<td>7. Ethylbromoacetate</td>
<td>0.0030</td>
<td>21.0000</td>
<td>2.30</td>
</tr>
<tr>
<td>8. Phenylcarbilamine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chloride</td>
<td>0.0030</td>
<td>2.1000</td>
</tr>
<tr>
<td>9. Bengylbromide</td>
<td>0.0040</td>
<td>0.0024</td>
<td>4.50</td>
</tr>
<tr>
<td>10. Acrolin</td>
<td>0.0070</td>
<td>20.0000</td>
<td>0.35</td>
</tr>
<tr>
<td>11. Bromomethylethyl-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ketone</td>
<td>0.0126</td>
<td>34.0000</td>
</tr>
<tr>
<td>12. Chloroacetone</td>
<td>0.0180</td>
<td>0.1200</td>
<td>2.30</td>
</tr>
<tr>
<td>13. Iodoacetone</td>
<td>0.0012</td>
<td>0.0031</td>
<td>1.90</td>
</tr>
</tbody>
</table>

vii. **INCAPACITATING AGENTS**²⁰:

Incapacitating agents are quite distinct from harassing agents, such as tear or vomiting agents where the effects are brief, true military incapacitants may be effective for several hours or even days. They are intended to incapacitate without killing except in very unusual circumstances. There are two approaches, physical or mental incapacitation, but both carry problems which have still to be solved.
For physical incapacitation, the problem has been to find agents which caused a disabling symptoms such as muscle paralysis, interference with the voluntary control of limbs, unconsciousness or loss of sight, but would be very unlikely to cause death. Those which affected neural transmissions between muscles offered the best likelihood of incapacitation but are also the most dangerous. For example, the haloalkylcarbamoxyalkyl derivatives and quaternary quinuclidinones, have safety ratios of only 10 to 40 respectively. Others are even more dangerous, two neuromuscular inhibitors, for example, have safety factors of only 1.8 to 3.1.

Psychological incapacitants seems to offer a more fruitful approach because they have far higher safety ratios. These act on the brain provoking temporary mental aberrations. They constantly produce changes in thought, perception and mood, without causing major disturbances of the autonomic nervous system. The best known is LSD. The principal drawback of this special type of weapon is that it provokes unforeseen and uncontrollable reactions in its victim.

LSD (Lysergic acid diethylamide)\textsuperscript{21} is the most powerful hallucinogen known, as little as 2 micrograms per kilogram of body weight can induce hallucinations and mental disorientation for 1 to 6 hours or more. The equivalent
dosage for mescaline, by contrast, is about 5 mg. per kilogram, some 2500 times the minimum LSD dose. But LSD appears to have been rejected because of comparatively high cost of large scale production and suspicion, that its use might cause long term genetic damage.

Cannabinoid agents also incapacitate through hypotension imbalance in blood pressure that can lead to temporary unconsciousness. Mescaline (3,4,5 - trimethoxyphenethylamine) has several analogues which have been synthesized for the purpose.

BZ (3 - quidnuclidiny benzilate)\(^{22}\), an extremely potent psychoactive chemical is a member of the glycolate family and belongs to a subgroup of powerful psychoactive chemicals. It is 10 times more powerful than LSD. BZ is a crystalline solid at normal temperatures and is sufficiently stable to be disseminated as a smoke from a pyrotechnic device. Symptoms of exposure to BZ may include vomiting, stupor and a lack of co-ordination and occur with in an hour or so. After this mental disorientation and hallucinations (both Audio and visual) may incapacitate the victim sometime to the point of immobility and maniacal behaviour may follow. Severe behavioural disturbances may last or reappear sporadically for the following two or three days until the drug finally
wears off.

Recent military research into incapacitating chemicals has concentrated on physiological rather than psychoactive agents such as benzilates EA-3167 and EA-3834 as potential successors to BZ. Instead of pursuing chemicals which affect the entire autonomic nervous system and carry a large risk of killing, researchers have investigated agents whose action would be specific to certain parts of the body, such as the nerve ganglia in the legs or brain. The victim would thus only be immobilized.

PERSISTENCY:

In accordance with the persistency, the chemical agents can be divided into two groups:23

i. Persistent agents.

ii. Non persistent agents.

The persistency of a chemical agent is determined by the length of time it will maintain an effective concentration without being renewed.

Chemicals that remain effective for longer than 10 minutes after release in the open are defined as persistent. Usually dispersed in liquid state, persistent agents contaminate the ground on which they are released
and continue to give off dangerous vapour for long periods.

Non persistent agents are those whose effectiveness in the open continues for less than 10 minutes. They vaporize rapidly, forming concentrated clouds that drift with the wind, increasing in size but becoming diluted in gas content until they finally disappear.

**TACTICAL CLASSIFICATION:**

Tactical classification, which is influenced by the persistency, is based on the primary military objective for which any particular chemical is used in the field. War gases are thus classified as casualty or harassing agents, smokes as screening agents, and the various fire producers as incendiaries.
<table>
<thead>
<tr>
<th>CLASS</th>
<th>COMMON &amp; CHEMICAL NAME</th>
<th>PHYSICAL STATE AT 68°F &amp; 760 mm. PRESSURE</th>
<th>RATE OF ACTION</th>
<th>PERSISTENCY</th>
<th>ODOUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Choking gas</td>
<td>Colourless gas</td>
<td>Immediate to 3 hr.</td>
<td>Nonpersistent</td>
<td>New-mown hay, green corn</td>
</tr>
<tr>
<td></td>
<td>Phosgene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Choking gas</td>
<td>Colourless liquid</td>
<td>Usually delayed 3 hr. or more</td>
<td>Moderately persistent</td>
<td>New-mown hay, green corn</td>
</tr>
<tr>
<td></td>
<td>Diphosgene</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Blister gas</td>
<td>Colourless to pale yellow liquid</td>
<td>Delayed usually 4 to 6 hr. but periods as late as 24 hr. or more have been observed.</td>
<td>Highly persistent</td>
<td>Garlic or horseradish</td>
</tr>
<tr>
<td></td>
<td>Distilled mustard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Blister gas</td>
<td>Dark liquid</td>
<td>Delayed 12 hr. or longer.</td>
<td>Persistent</td>
<td>Fishy or musty</td>
</tr>
<tr>
<td></td>
<td>Nitrogen mustard</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Blister gas</td>
<td>Dark oily liquid</td>
<td>Immediate irritation, delayed blistering.</td>
<td>Persistent</td>
<td>Geranium</td>
</tr>
<tr>
<td></td>
<td>Lewisite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Nerve gas</td>
<td>Colourless to brown liquid</td>
<td>Immediate to 15 min.</td>
<td>Moderately persistent to persistent</td>
<td>None when pure, otherwise faint fruity.</td>
</tr>
<tr>
<td></td>
<td>Tabun</td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>Nerve gas</td>
<td>Sarin</td>
<td>Colourless liquid</td>
<td>Immediate to 15 min.</td>
<td>Nonpersistent to slightly persistent</td>
</tr>
<tr>
<td>2</td>
<td>Nerve gas</td>
<td>Soman</td>
<td>Colourless liquid</td>
<td>Immediate to 15 min.</td>
<td>Persistent</td>
</tr>
<tr>
<td>3</td>
<td>Training agent</td>
<td>Chlorine</td>
<td>Greenish-yellow gas</td>
<td>Immediate</td>
<td>Nonpersistent</td>
</tr>
<tr>
<td>4</td>
<td>Blood gas</td>
<td>Hydrogen cyanide</td>
<td>Colourless gas or liquid</td>
<td>Immediate to 15 min.</td>
<td>Nonpersistent</td>
</tr>
<tr>
<td>5</td>
<td>Blood gas</td>
<td>Cyanogen chloride</td>
<td>Colourless gas</td>
<td>Immediate</td>
<td>Nonpersistent</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

Fruit with a purit odour camphor-like:

Pungent & resemble bleach powders:

Slight resemble bitter almonds:

Irritate & lacrimate:

Properties & odour:
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood gas</td>
<td>Arsine</td>
<td>Colourless gas</td>
<td>Delayed from 2 hr.to II days</td>
<td>Nonpersistent</td>
<td>Practical odourless when pure otherwise garlic smell (metallic taste)</td>
</tr>
<tr>
<td>Vomiting gas</td>
<td>Adamsite</td>
<td>Yellow to green solid</td>
<td>I min.</td>
<td>Nonpersistent</td>
<td>None</td>
</tr>
<tr>
<td>Tear gas</td>
<td>Chloracetophenone</td>
<td>Solid</td>
<td>Immediate</td>
<td>Nonpersistent</td>
<td>Apple blossom</td>
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BIOLOGICAL WARFARE AGENTS

Compared to chemical warfare, biological warfare has a pedigree almost as long as that of warfare itself. Ever since mankind started to fight with his neighbour attempts have been made to inflict hurt on an enemy by some how introducing illness to the squable. These agents involve the use of living organisms to attack the normal functioning of the human body to render an opponent ineffective. Primitive men, even though they had no idea of what bacteria or similar organism could be often sought to harm their enemies by introducing illness.

Biological warfare agents differ markedly from chemical warfare agents in that a living micro-organism will multiply a million fold in its life cycle so that an infinitesimal dose is enough to build up a dangerous infection in the human body. Once infection has started, there will be an incubation period of days or even weeks, according to the agent, before disease breakout. Since there is a certain time required before the symptoms of disease show up in a man, the agents could travel from a country to other countries, hidden inside the bodies of travellers.

It should not be forgotten that biological warfare agents can be utilized on animals and plants as well as
human beings. Disease such as swine fever can decimate animal herds, and populations dependent on a staple crop such as rice or maiz could be rendered helpless by the introduction of previously unknown specific plant disease. Insects such as the colorado beetle can destroy potato crops almost overnight and locusts can still reduce whole areas to virtual deserts within hours.

Toxins are also included in this section. These are extracted and purified from biological entities but are themselves not living and, in some cases, may be duplicated synthetically in the laboratory. These include the deadliest organic materials known and are known as biotoxins or often just toxins. The number of substances in this category are legion and many are well known.

It should also be kept in mind that biological warfare agent is an uncertain weapon. It takes time to take effect, is not always 100 percent effective and has a nasty tendency to be harmful to perpetrators as well as victim.

There are fine primary groups of micro-organisms from among which a biological warfare agent is likely to be drawn.

i. Rickettsiae.

ii. Bacteria.

iii. Viruses.
iv. Fungi.
And Toxins:

i. **Rickettsiae**²⁵

Rickettsiae are minute bacterium like micro-organisms visible with the light microscope. Like the viruses they are obligate intracellular, multiplying in living cells. These are primarily intestinal parasites of blood sucking arthropods such as lice, rat fleas, mites and ticks. These are the vectors that spread the disease to man. The disease caused by the rickettsiae are known as rickettsioses. Pathogenic rickettsiae invade different species of animals and men.

Rickettsia Prowazeki, the disease caused by it, is known as classic epidemic typhus. It is an acute infectious disease of man, characterised by severe headache, sustained high fever, general pains and a skin rash. Incubation is from 6 to 15 days averaging 12 days. Epidemics usually occur in winter under crowded and unsanitary conditions, particularly during famine and war, and when the population is heavily infested with body lice. The transmission is mainly by body lice which have fed upon infected persons.

Rickettsia Typhi²⁶ is another agent of this group, which causes disease named murine typhus. It
is very much similar to classic epidemic typhus except that the disease is milder and has a slower onset. The disease is transmitted from rodents to man by the bite of the rat flea. The incubation period ranges from 6 to 14 days mostly 12 days, susceptibility is general. One attack confers immunity, which sometimes is not permanent.

*Rickettsia Tsutsugamushi*\(^2\) causes scrub typhus, which is an acute infection in man, is characterised by sudden onset with chills and fever and headache which may increase in intensity. A dull red eruption appears on the trunk of the body on the 5th to 8th day, and may extend to the arms and legs. Coughing and other signs of pneumonia are frequently present. Transmission to man is made by the bite of infected larval mites.

*Rickettsia Rickettsii*\(^2\), causes Rocky Mountain spotted fever, it is an acute infectious disease characterised by fever and joint and muscular pains. The distinctive feature that distinguishes this fever from many other diseases is a measles-like rash on the palms of the hands and the soles of the feet. A skin rash usually appears on the 3rd or 4th day, rapidly spreading from the ankles and wrists to the legs, arms, and chest. The disease is transmitted by the bite of an infected tick, by contamination of abraded skin with infected tick tissues or faeces or by contact of tick tissues with unbroken skin.
The incubation period is from 3 to 10 days.

*Coxiella Burneti*, is a bacterium like gram-negative organism which causes fever, characterised by an acute fever of sudden onset, headache, chills, weakness and severe perspiration. Pulmonary involvement occurs in the majority of cases, accompanied by mild cough, scanty expectoration, and chest pain. As a biological warfare agent, Q fever is comparatively stable and extremely infectious with one micro-organism being capable of producing symptoms. Cows, sheep, goats, ticks and wild animals appear to be natural reservoirs. In man the disease is transmitted by the inhalation of infected dust as well as by ingestion. Raw milk from cows and goats, dried milk, raw wool, hides infected meat as well as culture of infected tissues, have been involved in infections. The incubation period is from 14 to 26 days.

*Rickettsia Akrai*, is responsible for rickettsialpox, which is a general infectious disease with an incubation period of 10 to 12 days. Its characteristic features are fever and an abundant vesiculo-papular rash resembling that in chickenpox, appears on the 3rd or 4th day of the disease. *Rickettsia* are revealed in patient's blood during febrile period. They are intracellular and extracellular parasites and multiply readily in the lungs
of white mice during intranasal infection. House mice and grey mice and grey rats are the reservoir of the infection. The vectors are capable of transovarial transmission and as a result of it they are also the reservoirs of the infection in nature.

ii. **BACTERIA:**

Bacteria are unicellular organisms which lack chlorophyll. Because of their biological properties and methods of reproduction, predominantly by binary fission they belong to the class Schizomycetes, order-Eubacterials. The shape as well as the dimensions of microbes is not absolutely constant. Morphological differences are found in many bacterial species.

Bacteria are living cells that have to maintain life. Many can do so in an external environment such as soil. Others prefer the living body of animals or man. But a parasite does not necessarily cause disease. A few invade the tissues, and compete with the host for nourishment with resulting injury to structure and function. The bacteria which produces disease are called pathogenic bacteria. Some of them are described under:

**Bacillus Anthracis** is a rod shaped, gram positive, aerobic sporulating micro-organism, the spores
constituting the usual infective form. The spores are very stable and may remain alive for many years in soil and water. They will resist sunlight for several days. Steam under pressure or exposure to dry heat above 159°C for an hour are necessary to kill spores.

Anthrax\textsuperscript{30} is principally a disease of herbivorous animals (cattle, sheep, horses and mules). In animals, anthrax occurs as an acute febrile septicaemic infection characterised by depression, weakness, difficult breathing, bloody diarrhoea and swellings in the neck, chest, flank and lumbar regions. The spleen becomes enlarged and liver damage. Contaminated soil, food, water and dust are sources of infection.

Anthrax may appear in three forms in man, cutaneous, pulmonary and intestinal. The cutaneous or skin form is also referred to as malignant pustule, occurring most frequently upon the hands and forearms of persons working with infected livestock, and is characterised by carbuncles and swelling at the site of infection. The pulmonary form is an infection of the lungs contracted by the inhalation of the spores, it occurs mainly among workers handling infected hides, wool and furs. The intestinal form, which is rare in man is contracted by the ingestion of insufficiently cooked meat from infected
animals. Cattle, sheep and horses are the chief animal hosts. Transmission is made through scratches or abrasions of the skin, wounds, inhalation of spores or by flies. Incubation is from 1 to 7 days. It is usually less than 4 days and may be less than 24 hours in pulmonary cases. The disease is not epidemic in man.

Brucella Group31, in this group are included three closely related organisms, Brucella melitensis, Brucella abortus, and Brucella suis. All are non-motile, non-sporulating, gram negative, rod shaped bacilli. The disease produced by this group is known as Brucellosis. In man, it is characterised by irregular prolonged fever, profuse sweating, chills, pain in joints and muscles and fatigue. Brucella abortus is a parasite of milk Cows, producing contagious abortion in cattle, the organism has also been reported in mares, sheep, rabbits, and guinea pigs. Brucella melitensis is primarily a strict parasite of goats and sheep, Brucella suis is a parasite of swine. These diseases are transmitted to man by the ingestion of contaminated milk and other dairy products, pickled meats, and uncooked foods and water contaminated by the excretion of infected animals and by direct contact with infected animals or animal products. Infection has also occurred by inhalation and by accidental inoculation among laboratory workers. Incubation is from 6 to 60 days or more, averaging 14 days.
As far as in animals, are concerned, Brucella abortus is the most common cause of this disease. It is mainly a disease of bovine animals. The disease may exist and persist in the genital system of the bull without evident symptoms. In pregnant cows it is characterised by a chronic inflammation of the uterus followed by abortion, results in injury to the uterus that may affect future pregnancies. Brucella melitensis produces Malta fever and contagious abortion in animals. Inflammation of the udder may be present in severe cases, but it is not until late in the disease that the milk undergoes any noticable change or milk secretion diminishes. Brucella suis causes brucellosis of swin. As with the other forms, it can result in contagious abortion, although this does not always result, that is, abortion is not the disease but rather a symptom that is sometimes observed.

Malleomyces Mallei, is a slender, non-motile, non-sporulating, gram-negative aerobic, rod shaped bacterium. It is pathogenic for both man and animals. Glanders, an infection occasionally communicated to man, is characterised by nodular, ulcerative lesions of the skin, mucous membranes and viscera. It is an acute or chronic disease mainly of horses, mules and asses, communicable to dogs, goats and sheep. The acute form is limited to the nasal mucosa and upper respiratory tract, the chronic form, called Farcy,
is characterised by farcy buds, ulcers, and pus-forming lesions in the joints and muscles. Infected horses, mules and asses are the sources of infection. Transmission is usually made by droplet infection (inhalation) or through breaks in the skin, it is sometime made through the gastrointestinal tract. Incubation is from 3 to 5 days.

Malleomyces Pseudomallei\textsuperscript{32} causes melioidosis, also known as whitmore's disease is a glanders-like disease primarily of rodents but occasionally found in man. It tends to run a more rapid course than glanders does and in man is almost always acute and rapidly fatal, death occurring usually in 3 to 4 weeks, often with in 10 days. The disease is characterised by sudden onset with severe chills, high fever rapid prostration, headache, muscle and joint pains, cough, laboured breathing, nausea and vomiting. Probable sources of infection are food or other materials contaminated with rodent excreta and possibly rat fleas. Transmission takes place apparent by the ingestion of food contaminated with excreta from infected rats and by rat flea bites. Although not accurately known, the incubation period is probably only a few days.

Salmonella Typhosa, bacterium causes typhoid fever, which is a systematic infection characterised by continued fever, lymphoid tissue involvement, ulceration
of the intestines, enlargement of the spleen, rose-coloured spots on the skin, diarrhoea and constitutional disturbances. The faeces and urine of infected individuals and carriers are sources of infection. Transfer of organisms is made through the alimentary tract by direct or indirect contact with a typhoid patient or a chronic carrier by consumption of contaminated water food, milk or shellfish, and by flies. Incubation is from 3 to 38 days, usually 7 to 14 days.

**Salmonella Paratyphi and Salmonella Schottmuelleri**, **S. Paratyphi** is responsible for paratyphoid fever which is very similar to typhoid fever, but its symptoms are usually milder. It is characterised by continued fever, severe diarrhoea, and abdominal pain, with involvement of the lymphoid tissues of the intestines, enlargement of the spleen and sometimes rose coloured spots on the trunk. **S. schottmuelleri** is responsible for more cases of the disease and may produce gastro-enteritis. The contaminated faeces and urine of patients and carriers are the sources of infection. Transfer of organisms is the same as far typhoid. Incubation is variable from 1 to 10 days depending on strain of organism but averaging less than a week.

**Salmonella Typhimurium** causes gastro-
enteritis in man. The onset of the infection is nearly always sudden, characterised by headache, chills, and usually by abdominal pains. This is followed by nausea, vomiting, severe diarrhoea with a rise in temperature and prostration. The sources of infection are usually rodents, especially rats and mice, human carriers who handle food, eggs and meat from diseased animals. The disease is usually obtained by the ingestion of contaminated food, water or milk. Food poisoning occurs after an incubation period ranging from 6 to 24 hours but seldom after more than 48 hours.

Mycobacterium Tuberculosis$^{33}$, Pulmonary tuberculosis caused by this bacterium is characterised by severe lung involvement accompanied by coughing, fever, fatigue, and loss of weight. The primary type is acute, healing or progressing in a relatively short time, and is most commonly seen in infants and children and occasionally in adults who have escaped childhood infection. Susceptibility to the disease is dependent upon age, race, family characteristics, and previous exposure to the organism. Tuberculosis infection in the bones, joints, skin, or other tissues is usually caused by the bovine variety of this organism, although this type may also invade the lungs. Infection is acquired from persons with draining lung cavities. Tuberculous cattle, and particularly
their raw milk, is the source of the bovine variety. The transmission usually occurs through the discharges of the respiratory tract, by direct or indirect personal contact. Natural infection usually requires continued and intimate exposure. The period is variable, depending on dosage, age, and other factors, but probably is not less than one month. The period may be reduced considerably by exposure to heavy concentrations of the organism.

*Shigella Dysenteriae*[^34], Bacillary dysentery is caused by this bacterium, is an infectious disease of man. It is characterised by mild or severe irritation of the lower gastro-intestinal tract accompanied by fever, abdominal pain, diarrhoea, weakness or prostration, and ulceration of the mucous membranes of the intestine. Faeces of infected human patients and carriers are the sources of infection. Transmission is made by the ingestion of contaminated food, water, or milk, by hand-to-mouth transfer of contaminated material soiled with faeces of a patient or carrier; or by flies. Incubation is from 1 to 7 days, usually less than 4 days.

*Vibrio Comma*[^35], is responsible for cholera, an acute infectious gastro-intestinal disease of man, characterised by sudden onset with nausea, vomiting, profuse watery diarrhoea with 'rice water' appearance, the rapid
loss of body fluids, toxemia, and frequent collapse. Epidemicity is very high under unsanitary conditions, especially those concerned with water supplies, foods and fly control. Faeces and vomitus of patients, faeces of convalescents, and temporary carriers are the sources of infection. Transmission is made through direct or indirect faecal contamination of water or food, by soiled hands or utensils, or by flies. Incubation is from 1 to 5 days, usually 3 days.

Corynebacterium Diptheriae, Diptheria caused by this bacterium, an acute febrile disease, is generally characterised by local infection, usually involving the air passages. The systemic manifestations are due to absorption of the soluble toxin into the blood stream. The bacteria multiply rapidly in the tonsils, nose and throat, causing sore throat swelling and stopage of air passages. During the first few days of infection, is only slight fever, and there are no severe constitutional symptoms. This lack of obvious symptoms is a characteristic of diptheria in the adult and is especially dangerous when infection occurs in the nasal passages, because the infection is not recognised or treatment is not begun until sufficient exotoxin has been absorbed to cause irreparable damage to other parts of the body. Discharges from the nose and throat of infected persons and healthy carriers or from skin lesions are
sources of infection. The disease is contracted by direct contact with patients or carriers, by droplet infection, or through articles freshly contaminated with nose and throat discharges of infected individuals. The incubation period is usually from 2 to 5 days.

Pasteurella Tularensis$^{36}$, disease caused by this bacterium, Tularemia also known as Rabbit Fever and Deer Fly fever. It is a fatal septicemic disease of wild rodents, accidentally communicable to man, in whom it is characterised by sudden onset with chills, fever, and prostration and by a tendency to pneumatic complications. In man it is an acute, severe, weakening disease, later becoming chronic, and may be accompanied by enlargement of the regional lymph glands with or without a lesion at the site of infection. Wild rabbit or hares, dear flies, ticks, and many other animals are sources of infection. Transmission is made by infection through the skin, eyes or lungs from handling infected animals, as skinning or dressing the animals or performing autopsies, by bites of infected flies and ticks, by eating in-sufficiently cooked rabbit meat, or by drinking contaminated water. Laboratory infections are not infrequent. Incubation is from 1 to 10 days usually about 3 days. The disease is essentially sporadic, but may be epidemic when modes of transmission
are prevalent. It is not transmitted directly from man to man.

*Pasteurella Pestis*, a bacterium is responsible for plague or black death, occurs as three clinical types in man, bubonic, pneumonic and septicemic. Another type of plague, sylvatic plague, is an infectious disease of wild rodents. In general, plague is characterised by a rapid clinical course with high fever, extreme weakness, glandular swelling, pneumonia, and/or haemorrhages in the skin and mucous membranes. Infected rodents and human patients with pneumonic plague are sources of infection. The primary source of the disease is plague of wild rodents, including the ground squirrel pack rats and harvest mice of the United States, and various species of wild rodents in other parts of the world. Infection may reach man from these sources of more often through the medium of the domestic rat. Pneumonic plague is usually transmitted directly from man to man by droplet infection. Bubonic plague is generally transmitted to man by the bites of fleas from infected rats and other rodents. Incubation is from 1 to 7 days for pneumonic plague, 4 to 7 days for bubonic plague.

### iii. VIRUSES:

The name virus was given by L Pasteur to many
causative agents of infectious disease. Viruses do not have a cellular structure and are small in size varying over a wide range from 10 to 350 μm. They live and multiply in the cells of live organisms but are also able to develop in homogenates of different organs. Many species of viruses are pathogenic for man also and cause number of diseases. Viral disease make up almost three fourth of all human infectious diseases. Many species of Virus are supposed to be the highly efficient biological warfare weapons.

Foot and Mouth disease virus, is a very small virus causes Aphthous fever, which is an acute, contagious, highly infectious, febrile disease of cloven-footed animals. Man is only slightly susceptible and, if infected, shows only mild symptoms. The disease causes a marked and rapid weight loss, a rapid decrease in milk flow, and a severely lowered reproductive capacity. It is characterised by an acute fever and by vesicle formation on the feet and mucous surfaces of the mouth and cheeks and on the udder. Infected animals and contaminated food, water, milk and pastures are the sources of infection. Transmission is by the ingestion of food, water and milk contaminated with urine, saliva, vesicular fluid, faeces and by direct contact. The disease has very high communicability. It tends to spread rapidly over a wide geographic area. Incubation is usually from 24
hours to 7 days, occasionally 2 or 3 weeks.

Rinderpest Virus, is responsible for cattle plague. It is an acute, febrile, highly contagious and highly fatal disease of bovine animals, sheep, goats, and water buffaloes. It is characterised by sudden onset, croupous inflammation of the digestive tract, inflammation and erosion of the mucous membranes of the mouth, and bloody diarrhoea. Infected animals are the sources of infection. Transmission is by ingestion of food and water contaminated with the urine, faeces, saliva and eye and nasal secretions and by direct contact. Incubation is from 3 to 9 days. Epidemicity is very high in non-immunised animals, as the disease is highly infective.

Rift Valley fever virus, it is a highly infective and fatal disease of sheep, goats and cattle are sometimes affected, and the disease is easily transmitted to man, in whom it usually takes a mild form. In sheep, the infection is characterised by a rapid course, high fever, loss of appetite; it may produce abortion in pregnant females. Infected animals are the sources of infection. The disease is transmitted by the bites of mosquitoes and possibly by the inhalation of infected food. Incubation is from 1 to 4 days for adult animals, 12 to 24 hours for lambs.
Vesicular Stomatitis Virus\textsuperscript{39}, Vesicular stomatitis also known as mouth thrush, is a contagious, weakening, febrile disease, primarily of horses and mules and occasionally of cattle and swine. It is characterised by vesicular eruptions of the mucous membranes, particularly of the mouth. Occasionally, lesions may be found on the feet and udders. Transmission is by ingestion of contaminated food and water and by direct contact. Horses, mules and cattle infected with the disease are sources of infection. Incubation is from 2 to 9 days.

Vesicular Exanthema Virus. Vesicular Exanthema is a contagious, febrile, weakening disease of swine. It is characterised by the formation of vesicles or lesions in the mouth and nostrils, on the snout, feet and udders, and around the coronary band. Animals become lame and hoofs are sometimes shed. Transmission is by direct contact, by the ingestion of contaminated food and water, and by persons going from farm to farm. The incubation period is from 2 to 7 days.

Hog Cholera Virus\textsuperscript{40}. Hog Cholera, also known as swine fever, is a highly acute, contagious, febrile disease of swine. It is usually chronic in order swine. It is characterised by high fever, yellowish discharges from the eyes, diarrhoea, loss of appetite, Viremia and extreme
weakness. Transmission is by contaminated garbage and through food, water, hog wallows and pens that have been contaminated from eye and nasal secretions, urine, blood and faeces of infected swine. Aerosol transmission is possible. Incubation is from 5 to 6 days.

African Swine fever virus. African swine fever also known as wart Hog disease, is a highly contagious and excessively acute disease of domestic swine. It is characterised by fever, pronounced haemorrhages of the lymphatic glands, the kidneys, and the mucosa of the alimentary tract, and by marked cyanosis of areas on the skin. It is mechanically spread by caretakers and other who pass from infected premises without taking proper precautionary measures. The incubation period is usually 4 to 7 days when exposure is made by contact with infected pigs. In epidemics the disease may occur in cent percent of susceptible domestic swine. At present there is no effective treatment for the disease.

Fowl plague virus, Fowl plague also known as fowl pest, is an acute, contagious, highly fatal disease of fowl, characterised by haemorrhages in various tissues of the body, swelling and blood poisoning. Transmission is by the ingestion of food, water and soil contaminated by the blood, urine, faeces and eye and nasal secretions from
infected fowl or birds, by infection through wounds, and possibly by blood sucking insects. Once the disease is introduced into a flock, it tends to spread rapidly and kills all or nearly all the flock in a short period of time. Infected fowl are sources of infection. Incubation is from 2 to 7 days, it may be as short as 24 hours.

New castle disease virus\(^{41}\). New castle disease, is an acute, highly contagious, febrile disease of fowl. The course of the disease is of short duration. It is characterised by severe respiratory and nervous symptoms, including difficult breathing, depression and stupor, twitching of the head and neck, marked weakness and perhaps paralysis. Infected fowl are sources of infection. Transmission is by direct contact, by the ingestion of food and water contaminated with faeces, and by the inhalation of contaminated dust. Incubation is usually 4 to 8 days, although it may be up to 13 days. No treatment has been developed so far.

Equine Encephalomyelitis Viruses. There are several viruses, each specific for the different forms of the disease. This disease is an acute infectious disease of the central nervous system of horses and mules and also of man. It is characterised by fever, drowsiness or restlessness, poor co-ordination, and occasionally convulsions,
in the severe cases motor and sensory paralysis cause prostration, and death results from respiratory and cardiac failure. Birds, and probably many wild and domestic animals, may become infected and serve as temporary reservoirs for the virus. The infection is transmitted by blood-sucking arthropods (usually mosquitoes) and perhaps by ticks, from the animal reservoirs to horses, mules and man. The disease tends to spread rapidly over local areas when insect vectors are present. The incubation period is variable, ranging from 2 to 15 days.

Psittacosis Virus. Psittacosis also called parrot fever, is a severe febrile disease in man. It is characterised by acute pulmonary infection. Chills, fever, anorexia, sore throat, severe headache, backache, constipation, great weakness, and prostration and is sometimes accompanied by delirium. Parrots, parakeets, budgerigars, canaries, pigeons, and other birds are sources of infection. The respiratory tract is the principal entry path. Transmission is made by contact with infected birds or by breathing air contaminated by faeces, urine, nasal discharges or the soiled feathers of sick, dying, or latently infected birds. Apparently well birds (carrier) can transmit the infection and in rare instances man has become a carrier. Incubation is usually 6 to 15 days.
Influenza virus\textsuperscript{43}. Influenza is an epidemic disease, which is characterised by catarrhal inflammation of the respiratory tract, sudden onset, fever of 1 to 7 days duration, marked prostration, and generalised aches and backache. Sore throat, bronchitis, and pneumonia are complications of secondary infections. Soiled articles and discharges from the mouth and nose of infected persons are the main sources of infection. Transmission is probably by direct contact, by droplet infection, or by articles freshly contaminated with nose and throat discharges of infected individuals. The incubation is from 1 to 2 days.

Variola Virus\textsuperscript{44}. Causes smallpox, a highly contagious and often fatal disease, is characterised by severe fever and small blisters of the skin. The blisters later contain pus and form crusts which fall off in 10 to 40 days after the first lesions have appeared, leaving pink scars which gradually fade. Complications of the disease are secondary bacterial infections. Lesions of the mucous membranes and skin of infected persons are the sources of infection. Transmission is made through contact with patients having the disease or with articles or persons freshly contaminated by discharges from lesions and skin of infected individuals.

Yellow fever Virus\textsuperscript{45}. Yellow fever is a
highly infectious disease and is characterised by sudden onset, chills and fever, prostration, headache, backache, muscular pain, congestion of mucous membranes, jaundice from liver damage. Actually, it is primarily a disease of monkeys and other jungle animals, but it is readily transmitted to man. The blood from people and monkeys infected with yellow fever is the source of infection. Transmission is usually by the bite of the female aedes aegypti mosquito. Incubation is from 3 to 6 days, rarely longer.

Dengue fever virus. Dengue fever, an acute, extremely disabling disease usually of sudden onset, is characterised by fever, chilliness, intense headache, backache, pain behind the eyes, joint and muscle pains, weakness and prostration, and an irregular rash. Dengue fever is said to be temporarily the most incapacitating although the least fatal of epidemic disease. Sources of infection are the blood of infected persons one day before and up to 5 days following onset, infected mosquitoes, and in some regions possibly the blood of infected monkeys. The disease is transmitted by the bite of the Aedes aegypti mosquito which has become infected by biting a patient.

Hepatitis Viruses. There are two strains of Hepatitis virus, virus A or infectious hepatitis and Virus B or serum hepatitis. These both hepatitis are
characterised first by fever, loss of appetite, nausea, fatigue, headache, and abdominal discomfort. After a few days the fever subsides, then because of liver damage, bile may be present in the urine and jaundice appears. Sources of infection of virus A are discharges from the nose, mouth, and gastro intestinal tract of infected persons. Sources of infection of virus B are blood, serum or plasma from infected persons. The usual mode of transmission for virus A is unknown but virus B is transmitted by transfusions of infected blood, serum or plasma. The sharing of infected medical instruments such as by drug addicts, is a common cause of transmission. Incubation is long and variable—15 to 40 days for Virus A, 40 to 150 days for Virus B.

iv. FUNGI:

Fungi are plants that lack chlorophyll and can not conduct photosynthesis, so they live on other organisms or on decaying organic matter. They are therefore either saprophytic or parasitic. Fungi are extremely common and are widespread in distribution, but fortunately only a few of them are pathogenic. The warmth and humidity of the tropics are particularly favourable for their multiplication. The line that separate them from the bacteria is tenuous in some instances. They are more resistant than bacteria
to drying, alcohol, and the action of antibiotics, which after all are derived primarily from fungi.

*Coccidioides immitis*[^47]. In man and animals, this fungus occurs as thick walled endospore-filled spherules and appears as a fluffy white cottony mould. It is responsible for coccidioidomycosis, which is a highly infectious disease. The usual primary form is an acute, disabling, selflimiting respiratory infection resembling influenza with usually a low grade fever, and a slight cough. The secondary, progressive form is a chronic, malignant, disseminated infection which involves any and all organs of the body, including the skin and bones, and produces numerous abscesses. A primary localised form of infection may occur on the exposed surfaces of the skin. Dust, soil and vegetation contaminated with spores of this fungus are sources of infection. Transmission is made by inhalation of spores in dust from soils and dry vegetation and possibly through skin scratches or wounds. The incubation period for the primary pulmonary form is 10 to 21 days, the average being about 12 days. The disease is noncontagious. Small epidemics may occur in hot, dry seasons when large numbers of individuals, such as military units, are stationed in endemic areas or engaged in manoeuvres in these areas.
Histoplasma Capsulatum. The fungus appears as small oval, yeast-like intracellular bodies in the tissues of man and animals. Histoplasmosis, the disease caused by this fungus is a chronic, local or systemic, infectious disease of man and other animals. It is characterised by low grade granulomatous lesions of the skin and tuberculosis like lesions on the lungs and by involvement of internal organs, especially the spleen and liver. Dust contaminated with spores of this fungus is a source of infection. The agent has been recovered from man, dogs, cats, rodents, skunks, and opossums and from the soil and water. The transmission is usually by inhalation of spores in dust from soils and dried organic matter, it may also be transmitted by ingestion or through skin scratches. In the few reported epidemics, symptoms appeared within 5 to 18 days. The disease is non-contagious.

Nocardia asteroides. This aerobic fungus has characteristics of both moulds and bacteria and has been classified in an intermediate position. The disease caused by this Nocardiosis, a severe pulmonary infection, is similar in many respects to tuberculosis but tends to form numerous abscesses instead of tubercules and is characterised by chronic pneumonia. It tends to spread to other organs of the body, especially the brain, where abscesses are formed. Pulmonary infection is characterised by a general malaise,
fever, a productive cough, night sweats, loss of appetite, and loss of weight. Brain involvement presents symptoms of headache, nausea and vomiting soil, dust or vegetation contaminated with the organism are the main sources of infection. The disease is transmitted by contaminated dust and possibly by droplet infection or through pus and other discharges from infected individuals. Skin infections usually result from contamination of wounds or scratches. The incubation period in man is unknown; experimental infection in guinea pigs is usually fatal with in a week.

v. TOXINS:

The clear scientific distinction between 'Chemical' and 'Biological' does not always apply in the way agents are classified and discussed. The 1972 biological warfare convention includes a class of chemicals which are extracted and purified from biological entities but are themselves not living and, in some cases, may be duplicated synthetically in the laboratory. These include the deadliest organic materials known and are known as 'biotoxin' or often just 'toxins'. They fall into three main subdivisions.

i. Phytotoxins : Which are vegetable-based.

ii. Zootoxins : are found in animals, eg. snake venom, certain species of frogs and fish are sources for some of the world's most deadly poisons.
iii. Microbial toxins: are found in fungi and bacteria.

With a few important exceptions, toxins based on protein are the most lethal but they also tend to have higher molecular weights, which proved a draw back in trying to turn them into battlefield weapons.

Ricin\(^{50}\), a castor bean based poison, has been widely known and studied for years. It is one of the most deadly known poisons in the world and is some 25,000 times as toxic as strychnine. Ricin apparently consists of glycoprotein bands which divide into two peptide chains (A and B) upon attacking a cell. The A chain, and possibly the B Chain as well, enters the cell and carries the toxic constituent into the cytoplasm. There is no known effective antidote and Ricin is extremely difficult to trace in a postmortem. In a watery solution, ricin becomes unstable at temperatures above 60 to 75 degrees centigrade and, in a solid form, after about 100 degrees.

Botulinum toxin, formed by the botulinum bacillus, has received most military attention. Through repeated purification procedures, it has been obtained in a crystalline form. There are at least five distinct types A, B, C, D and E, of which types A, B and E are known to be toxic to man; C and D are toxic for animals and probably for man. Botulism is a highly fatal, acute poisoning. It
is characterised by vomiting, constipation, thirst, general weakness, headache, fever, dizziness, double vision, paralysis of the muscles involved in swallowing, and difficulty of speech. Respiratory paralysis is the usual cause of death. Sources of the toxin are bacteria *clostridium botulinum* and *clostridium parabotulinum*. The principal reservoir of the bacteria is the soil. Transmission is through eating of food contaminated with the toxin. Symptoms of poisoning usually do not appear until between 12 and 72 hours after food containing the pre-formed toxin has been consumed.

Saxitoxin\(^{51}\) (TZ) is a non-protein neurotoxin originally derived from California mussels and Alaska butter clams. The actual source is the plankton *Gonyaulax Catenella* which turns the shellfish poisonous when they feed upon it. Saxitoxin is much less toxic than ricin or botulin and is comparable to nerve gas in its lethality, but it is much more fast acting and stable poison than either of the other two.

\(T_2\), \(DA\), Nivalenol and Deoxynivalenol. All are among the toxins produced by varieties of Fusarium fungi such as *Fusarium tricinctum* of the trichothecen group. \(T_2\) toxin has also been isolated from *Trichoderma lignorum* which occurs in mouldy corn. Symptoms of trichothecone
poisoning include vomiting, blistering and internal haemorrhaging, while death is associated with lesions and haemorrhaging of the intestines, liver and kidneys. However the trichothecene toxins are relatively weak and this has caused some doubts as to their development into chemical weapons. Death from trichothecene poisoning is often prolonged and requires considerable dosages over an extended period of time. Therefore they are probably designed as incapacitants or rice pollutants. Many of the supposed chemical attacks have involved aircraft fired rockets emitting red or yellow smoke causing vomiting, diarrhoea and convulsions but few deaths.

*Staphylococcus* toxin, is produced in food by certain strains of *staphylococci*. It is an entero-toxin, since it has a specific action on the cells of the intestinal mucosa. It is usually characterised by sudden, sometimes violent onset, with severe nausea, vomiting, stomach cramps, severe diarrhoea, and prostration. The source of contamination is not known in most cases but is probably of human origin. Food implicated as sources of food poisoning are chiefly pastries, milk, milk products and meat. Food handlers who are nasal or skin carriers of pathogenic *staphylococci* or who have an open *staphylococcal* lesion on their hands, arms, or face have been traced as sources of poisoning. Incubation is relatively short. One half hour to 4 hours,
usually 2 to 4 hours, elapse between the taking of food and the appearance of symptoms. The toxin is probably the cause of acute food poisoning.

Batrachotoxin\textsuperscript{53} is a highly lethal non-protein poison some four and a half times as deadly as saxitoxin. It is used by the Indians of the choco rain forest in colombia as a tainting agent for blow-gun darts. When the poison first began to attract serious interest by toxicologists, the only source was the skin of the south American arrow poison frog. The practical difficulties were great and, the frogs did not travel well and the toxin, once was found to be very difficult to work with. However, a batrachotoxin derivative has been synthesized with a toxicity of 1 microgram per kilogram compared with 2 micro grams for the natural product.

Tetrodotoxin\textsuperscript{54}, an another agent which has attracted considerable military interest, and this has had the advantage of a reasonably accessible source. It is extracted from the viscera and sex organs of certain species of puffer fish from a scientific point of view, one of the toxin's most intriguing features is its chemical identity with tarichatoxin. Tetrodotoxin is a public health problem in Japan, where the puffer is regarded as a delicacy, and much of the considerable work on it comes from Japanese researchers. Tetrodotoxin's mechanism of action is similar
to that of local anaesthetics and death is due to respiratory failure.

**COMPARATIVE TOXICITIES (TOXINS)**

<table>
<thead>
<tr>
<th>AGENT</th>
<th>NATURE</th>
<th>SOURCE</th>
<th>APPROXIMATE DOSAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulinus toxin A(X)</td>
<td>p</td>
<td>Bacteria</td>
<td>0.00003</td>
</tr>
<tr>
<td>Tetanus toxin</td>
<td>p</td>
<td>Bacteria</td>
<td>0.001</td>
</tr>
<tr>
<td>Ricin (W)</td>
<td>p</td>
<td>Plant</td>
<td>0.02</td>
</tr>
<tr>
<td>Palytoxin</td>
<td>np</td>
<td>Coelenterate</td>
<td>0.15</td>
</tr>
<tr>
<td>Crotalus toxin</td>
<td>p</td>
<td>Rattlesnake</td>
<td>0.2</td>
</tr>
<tr>
<td>Diphtheria toxin</td>
<td>p</td>
<td>Bacteria</td>
<td>0.3</td>
</tr>
<tr>
<td>Cobra neurotoxin</td>
<td>p</td>
<td>Cobra</td>
<td>0.3 MLD in</td>
</tr>
<tr>
<td>Batrachotoxin</td>
<td>np</td>
<td>Frog</td>
<td>2.0 microgram</td>
</tr>
<tr>
<td>Kokoi toxin</td>
<td>np</td>
<td>Frog</td>
<td>2.7 per kilo-</td>
</tr>
<tr>
<td>Tetrodotoxin/Tarichatoxin</td>
<td>np</td>
<td>Fish/Newt</td>
<td>8.0 gram.</td>
</tr>
<tr>
<td>Saxitoxin (TZ)</td>
<td>np</td>
<td>Dinoflagellate</td>
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<tr>
<td>Bufotoxin</td>
<td>np</td>
<td>Toad</td>
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</tr>
<tr>
<td>Curare</td>
<td>np</td>
<td>Plant</td>
<td>500.0</td>
</tr>
<tr>
<td>Strychnine</td>
<td>np</td>
<td>Plant</td>
<td>500.0</td>
</tr>
</tbody>
</table>

Key:  
- **p** - protein.  
- **np** - non-protein.  
- **MLD** - minimum lethal dosage.
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