CHEMICAL & BIOLOGICAL WARFARE

BY

GRAHAM S. PEARSON, B.Sc., Ph.D., C.Chem., F.R.S.C.
(Director, Chemical Defence Establishment, Porton Down)

ABSTRACT

Key milestones in respect of chemical and biological warfare from antiquity to the present day are outlined. The difficulties associated with obtaining unequivocal evidence that chemical or biological warfare has been used is discussed. The present chemical and biological warfare threat is seen as a potential spectrum which extends from the classical CW agents through the bioregulators and toxins to the traditional biological warfare agents.

The key thrusts associated with the provision of effective chemical and biological protective measures are outlined, ranging from assessment of the hazard through detection, protection, monitoring and decontamination to medical countermeasures.

The arms control situation in respect of chemical and biological warfare is then addressed starting with the Geneva protocol of 1925, the Biological and Toxins Weapons Convention of 1972 and the ongoing negotiations for a comprehensive, verifiable and global ban on chemical weapons. Finally, the way ahead is addressed and the importance of strong defence against the threat of CBW even after a Chemical Weapons Convention and an improved Biological Weapons Convention is recognized as being essential to deter potential aggressors from considering breakout from such conventions.

Introduction

What is Chemical and Biological Warfare?

The term chemical and biological warfare (CBW) is little understood by the man in the street and little appreciated. In essence, it is the use of chemical or biological materials to cause harm to man or animals. Chemical materials are non-living and produce their effects by poisoning of the target population; on the other hand, biological materials infect the target population.

The use of such materials to attack plants is somewhat indeterminate: the Biological and toxin Weapons Convention prohibits the use of biological agents and toxins against man, animals and plants, whereas the draft Chemical Weapons Convention being negotiated at the Conference on Disarmament in Geneva is concerned with the prohibition of the use of chemical agents including toxins against man and animals. The role of herbicides is excluded from the current rolling text.

U.K. Policy

Although the United Kingdom had a retaliatory chemical warfare (CW) capability in World War I and maintained this throughout World War II (at which time the U.K. investigated a retaliatory biological warfare (BW) capability as well), in the late 1950s the decision was taken to abandon offensive CW. Consequently, since that time the U.K. has been solely concerned with the provision of effective protective measures for the U.K. Armed Forces against the threat that chemical or biological weapons might be used against them by an aggressor. A key strand in U.K. policy is to take a leading role in the Conference on Disarmament in Geneva to ensure that an effective ban against chemical weapons is achieved. The Biological and toxin Weapons Convention was signed on 10 April 1972 with three nations, the United Kingdom, the United States of America and the Union of Socialist Soviet Republics being co-depositaries. Negotiations towards a comprehensive, verifiable and global ban of chemical weapons have been in

progress in Geneva over the past decade and are making steady progress towards a more intrusive regime than any hitherto negotiated.

Historical Perspectives

Use of Chemical and Biological Warfare

Chemical and biological warfare goes back into the mists of antiquity. After all, the use of pyrotechnics and smoke mixtures to asphyxiate was known at a very early date. TABLE I includes some of these early conflicts in which CBW is alleged to have been used.

In more recent years, there have been increased allegations that CBW agents have been used and TABLE II comes from a Parliamentary Question answer by the then Foreign Officer Minister, Mr David Mellor[1].

TABLE I—*Milestones in chemical and biological warfare*

673 BC	'Greek fire' at Siege of Constantinople
	Contamination of water supplies
600-200 BC	Greek use of smoke
190 BC	Hannibal naval victory using venomous snakes
1710	Russians throw bodies of plague victims into Swedish city
1763	British use of smallpox-contaminated blankets (Fort Pitt, Ohio)
1797	Napoleon attempt (Italian campaign) to infect with swamp fever
World War I	Large scale use of CW
1925	Geneva Protocol
1935-38	Ethiopia
World War II	Unit 731, Japan
1951-53	North Korea and China allegations
1957	Oman allegations
1960s	Vietnam war allegations
1963-67	Yemen
1972	Biological Weapons Convention
1979	Sverdlovsk anthrax outbreak
1980s	Yellow rain in SE Asia
1980s	Afghanistan
1980s	Middle East requests for cultures
1985-1988	Iran-Iraq war

TABLE II—*Allegations of use of CBW, 1977-1988*[1]

Laotian and Vietnamese forces in Laos	Indonesian forces in East Timor
Vietnamese forces in Kampuchea	Philippines Armed Forces in Mindanao
U.S. covert action (CIA) in Cuba	Nicaraguan forces
Soviet forces in Afghanistan	Angolan (Cuban/Soviet) forces against UNITA
Ethiopian forces	Sudanese Peoples' Liberation Army
Iraqi forces in Iran	Chadian forces
Salvadoran Army in El Salvador	Libyan forces in Chad
South African forces in Angola and Namibia	Mozambique forces
Burmese army	Philippines forces
Guatemalan forces	

Difficulty of Proof

In the reply to the Parliamentary Question, it was made clear that many of these allegations are unsubstantiated or unproven. Why such uncertainty? Therein lies one of the subtleties of chemical and biological warfare in that use does not necessarily lead to a clearly recognized signature. There are two points to consider:

(*a*) When a chemical agent enters the body, it immediately interacts with the chemistry of the body and it is thereby metabolized and broken down into component parts. If the chemical weapon casualty has been treated for his symptoms by use of a drug, the metabolizing of that drug will greatly increase the complexity of the already complex chemistry inside the body. It is all this, when working with samples from casualties, that makes the unequivocal determination of whether chemical agents have been used so very difficult. An analogy in every day life will make it very clear; we all recognize that whilst shortly after having a glass of wine, the alchohol content of the body will be detectably higher; within a day, there will be very little trace and the task of proving that a person had a glass of wine twenty-four hours ago let alone identifying the particular type of wine and vineyard is well nigh impossible. However, with chemical weapons as for wine, a spill upon the clothes or upon the surroundings is much more lasting and hence informative and can lead to clear answers.

(*b*) Insofar as biological warfare is concerned, such agents manifest themselves through infectious diseases. Here, it is vital to recognize that disease is rampant on the battlefield in any event. For example, in the Vietnam war in the mid 60s the vast majority of military casualties attending military hospitals were suffering from disease; the proportion of battle casualties was less than one in seven (see TABLE III). Although some BW agents can be unusual diseases for the particular locality in which they are used, it seems probable that an aggressor would choose to use an agent which might occur naturally, and consequently, not be recognized as such against a background of naturally occurring disease.

TABLE III—*Vietnam admissions to U.S. Army medical facilities (active duty Army patients, 1967)*[2]

Disease	76%
Non battle injuries	13·8%
Battle casualties	15·8%

Some casualties are classified under more than one heading

The U.K. expertise in regard to the analysis of alleged CBW samples is second to none and is based on the expertise of laboratories such as those at the Chemical Defence Establishment (CDE) at Porton Down and at the Admiralty Research Establishment at Holton Heath. Techniques have been developed which have been shown in international exchanges to be world leaders. It should however be stressed that an analytical capability alone will not suffice. All the collateral information about an alleged CBW attack needs to be taken into account; the reports of the attack, the description by eye witnesses of what happened, the evidence relating to the collection of the sample, the validation of the location from which the sample came and the sample transmission to the analytical laboratory, together with the forensic scientific handling of that sample, are all key factors that need to be addressed in a way that will stand up to international scrutiny. The U.K. has played its part in making technical contributions to a recent report by the United Nations Group of Experts who have been considering the investigations of allegations of CBW use.

The CBW Spectrum

The Concept

A decade ago it would have been adequate to describe the threat as comprising chemical weapons based on those known in World War I and extended by the nerve agents discovered first in Germany during and after World War II on the one hand and the biological warfare agents (the microbial organisms which have been examined for a retaliatory capability) on the other. The agents used in World War I are listed in TABLE IV and the properties of the chemical warfare agents known by the early 1950s are in TABLE V. The biological agents which were weaponized in the U.S. BW programme up to 1969 included the following:

Anthrax
Tularemia
Q-Fever
Venezualan equine encephalitis
Botulinum toxin
Staphylococcal Enterotoxin B

It has now become apparent that the range of potential CBW agents can best be described as a spectrum. A Polish Ministry of Defence statement[3] in 1983 recognized the move in this direction:

> At the present stage in the development of mass destruction weapons the differences between chemical and biological weapons have become less noticeable, and are expected to disappear altogether in the near future as a result of the application of biochemistry in the production of synthetic toxic agents.

The potential CBW spectrum extends from the classical chemical warfare agents such as mustard, nerve gases and hydrogen cyanide through toxic industrial, pharmaceutical or agricultural chemicals, the bioregulators and the toxins which are the products of living organisms to genetically manipulated microbial organisms and thus to the traditional biological warfare agents such as anthrax, tularemia and plague. The spectrum is illustrated in FIG. 1 and the distinction between CW and BW is seen to be imprecise. The only clear distinction in the spectrum is between the non-living chemicals, which poison the target population and are represented by the four left-hand boxes, and the living organisms, in the right-hand two boxes, which infect the target population. The term 'Agents of Biological Origin' which is sometimes used in discussions of CBW agents can be confusing in that this can embrace a range of both microorganisms and non-living chemicals.

In the spectrum, the potency generally increases from left to right in that at the biological end of the spectrum, a few micro-organisms are enough to

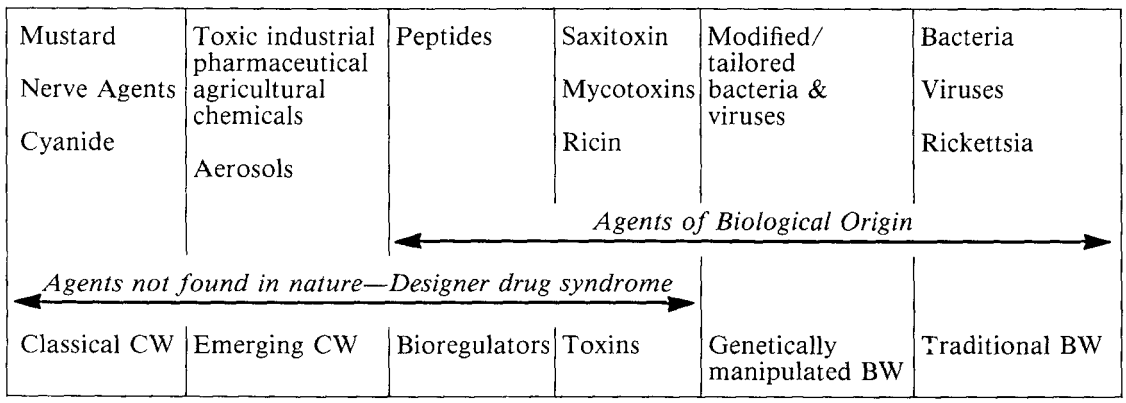


FIG. 1—THE POTENTIAL CBW SPECTRUM

infect whereas, at the chemical end, toxicities of the order of a mg per kg of body weight or less are typical. It is, however, essential to concentrate on toxicity in its widest sense, i.e. incapacitation as well as lethality. It is evident that incapacitation may serve an aggressor's objective more effectively than a lethal agent as incapacitation involves enemy manpower in looking after casualties and it may be regarded as more acceptable than lethality. After all, incapacitation is accepted in our daily lives when medical treatment is required.

The concept of a CBW spectrum is especially valid now as a result of the advances that have arisen from biotechnology. The past decade has seen the widespread application of biological systems in the production of an ever-wider range of materials and many substances that previously were only available in minute quantity from natural sources can now be produced by biotechnological means. Closely linked to this has been the increased interest of pharmaceutical companies in developing novel techniques for targeting the delivery of drugs to particular parts of the body. All of this means that the potential mid-spectrum agents have received far more attention over the past decade than ever before.

Definition Difficulties

In considering the CBW spectrum, it also needs to be recognized that the boundaries between the four boxes of non-living chemicals depend upon the definitions used, and that there is a danger that any legislation to control named chemicals can be circumvented through chemical modification. A particular example occurs in the drug abuse scene where the drug fentanyl is proscribed in southern California and possession of the drug can lead to prosecution in the Courts. This legislation has been circumvented by back-street chemists making slight modifications to the drug and thereby producing a different chemical which may be as potent or even more potent than the original material. Clearly, such chemical modifications could equally be applied to materials in one or other of the four left-hand boxes of the spectrum. Any Chemical Weapons Convention constructed only on the basis of lists of proscribed chemicals therefore carries the risk of such circumvention. For this reason, the draft Chemical Weapons Convention under negotiation in Geneva covers all toxic chemicals intended for use as chemical weapons.

Potential confusion arises on two accounts:

(*a*) The Biological and toxin Weapons Convention of 1972 applies to biological agents and to toxins. Neither of these are defined in the Treaty. It is, however, evident that the term 'biological agents' applies only to the microbial organisms that are living and are able to replicate themselves and infect the target system. The toxins, on the other hand, although the natural products of microbial organisms, are non-living and are strictly chemicals.

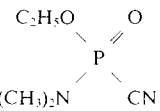
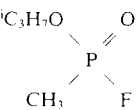
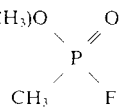
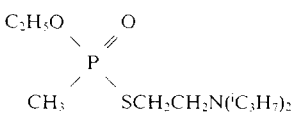
(*b*) The term 'agents of biological origin' is frequently used but has no standing in respect of the Biological and toxin Weapons Convention or other Treaty negotiations. 'Agents of biological origin' can cover a wider range of agents and, presumably, covers any material that is produced or can be produced by biological systems. It therefore embraces both non-living chemicals and living micro-organisms.

The concept of a CBW spectrum is presentationally advantageous as it ensures that protective measures are correctly targeted against the entire range of potential CBW agents and therefore avoids the pitfall of such protective measures having limited applicability, to only a small part of the spectrum. The spectrum represents the design goal and ensures that a comprehensive approach is adopted.

TABLE IV—*World War I: chemical agents used*

Chlorine	Hydrogen cyanide
Phosgene	Xylyl bromide
Diphosgene	Benzyl bromide
Mustard	Bromacetone
Diphenylchloroarsine	Bromomethylethyl ketone
Diphenylcyanoarsine	Dichloromethyl chloroformate
Chloropicrin	Methyl chlorosulphonate

TABLE V—*Some chemical warfare (CW) agents*

Code	*Common name & chemical structure*	*Boiling point* °C	*Vapour pressure* mm Hg	LCt_{50}* mg min m^{-3}	LD_{50}† mg/kg	ECt_{50}‡ mg min m^{-3}
Blood agents						
AC	Hydrogen cyanide HCN	26	638 (20°C)	2000	1·0	500
CK	Cyanogen chloride CNCl	13	1000 (20°C)	11000	—	7000
Choking agents						
CG	Phosgene $COCl_2$	8	1406 (25°C)	3200	—	120
Blister agents						
H	Mustard agent $(ClCH_2CH_2)_2S$	217	0·072 (20°C)	1250	0·2	100
L	Lewisite $ClCH=CHAsCl_2$	190	0·40 (20°C)	1300	0·5	20
HN-3	Nitrogen mustard $(ClCH_2CH_2)_3N$	256 (decomposes)	0·007 (20°C)	Slightly less toxic than sulphur mustard Hydrochloride (usual form) more aggressive than free base		
Nerve agents						
GA	Tabun 	240	0·035 (20°C)	300	0·08	100
GB	Sarin 	147	2·1 (20°C)	70	0.04	15
GD	Soman $(CH_3)_3CCH(CH_3)O$ 	210	0·34 (20°C)	50	0·01	15
VX	— 	320	0·0004 (20°C)	35 (aerosol droplets)	0·007	10

* LCt_{50}: The product of concentration (C) of a gas and the duration (t) of exposure which will kill 50 per cent of the exposed population.
† LD_{50}: The dose of a chemical that will kill 50 per cent of the population.
‡ ECt_{50}: The product of the concentration (C) of a gas and the duration (t) of exposure that will produce an effect in 50 per cent of the exposed population.

New CBW Agents

Finally, why should we be concerned about a spectrum? There are those who would argue that CW has reached a high degree of maturity and thus imply that there is little scope for new agents. Such an argument strains scientific credulity as it would appear possible that any nation which has an offensive CW capability might seek to enhance that capability in three ways:

(*a*) agents with increased toxicity;

(*b*) improved dissemination techniques;

(*c*) agents to defeat protective measures.

It is evident that new potential agents are being identified; for example, perfluoroisobutene (PFIB), a by-product of PTFE ('Teflon') manufacture, has been identified in the CWC negotiations as a material that has a similar toxicity to the classical CW agents and needs to be addressed by the Convention. Other novel toxic materials which may present a risk are being identified; these include peptides such as bradykinin which is a component of some wasp venoms and prostanoids such as PGF 2α. These both have toxic effects that require that these materials be considered. This entire area of chemicals is the subject of particular interest to the pharmaceutical industry.

The technology within the chemical industry associated with the production of new substances is not generally regarded as being high technology. It is certainly much lower technology than that involved in many other weapons systems and if one considers the armour/anti-armour scene, with its increasing sophistication, it will be noted that new tanks are fielded at about ten year intervals. As already noted, the classical CW agents are largely those used in World War I together with the nerve agents that date from World War II and the years shortly thereafter. The apparent absence of new improved agents over the past thirty or forty years cannot be put down to technical difficulty and leads to the question as to whether nations may have developed new CW agents, but have not admitted to such development or possession.

In this context, some of the statements quoted in a series of articles in *The Christian Science Monitor*[4] in 1988 make interesting reading:

> The country that uses new agents will have the surprise factor in their favor. In a chemical exchange, that can be decisive.
>
> (Lt-Gen Anatoly Kuntsevich,
> Deputy Head, Soviet Army Chemical Corps)

> At present, bioengineering is producing 'the same old substances'... [but] if we look into the future there could be things that surpass the lethality of known agents.
>
> (Nikita Smidovitch,
> Soviet Ministry of Foreign Affairs)

Delivery Means

In the initial stages of World War I, simple delivery means were used to disseminate chemicals on the battlefield. These included lines of gas cylinders which were simply opened when the wind was in the right direction. Later systems included mortars and subsequently advanced to shells. World War II saw the development of bombs, rockets and a wide range of artillery together with early spray systems. In subsequent years, little has been published about delivery systems although the Soviet Union and the United States have put on display their standard chemical weapons. The chemical weapons displayed by the Soviet Union at Shikhany in October 1987 are listed in TABLE VI and some examples are in FIG. 2. Those displayed by the United States in a subsequent return visit for the Soviet Union are listed in TABLE VII.

TABLE VI—*Chemical weapons displayed by the Soviet Union at Shikhany, 3-4 October 1987*

Agents
Mustard/Lewisite, Sarin, Soman, VX, CS
Munitions
2 missile warheads
6 artillery shells
4 rocket warheads
4 aircraft bombs
2 spray tanks
1 close combat (grenade)

TABLE VII—*Chemical weapons displayed by the United States at Tooele Army Depot, Utah, 19-20 November 1987*

Agents
Mustard, Sarin, VX, BZ
Munitions
105 mm, 155 mm, 8 inch shells (GB)
4.2 inch shell (H)
binary shell (GB2)
3 bombs (GB)
2 cluster bombs (BZ)
115 mm rocket (GB)
2 spray tanks (GB, VX)
mine (VX)

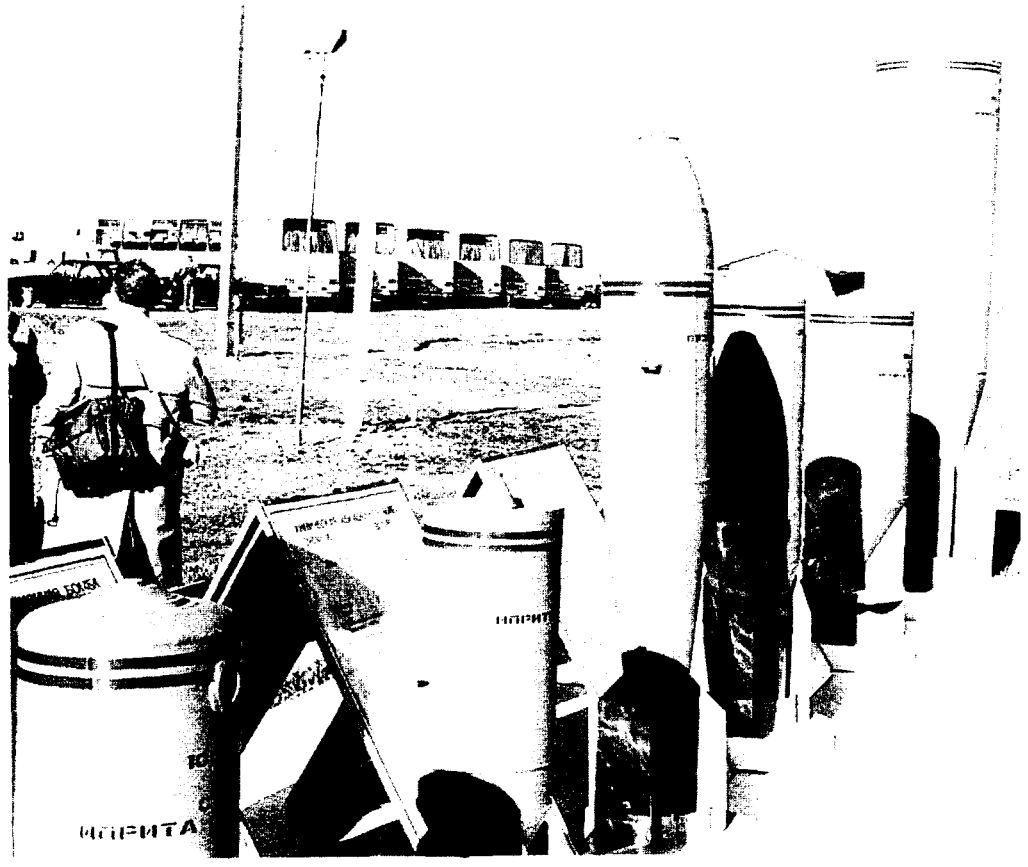


FIG. 2—SOVIET CHEMICAL WEAPONS AT SHIKHANY, OCTOBER 1987

Chemical and Biological Defence

The provision of effective chemical and biological defence rests on a number of interrelated activities. The first essential is the assessment and evaluation of the hazard. This comprises several strands:

(*a*) *Identification of the potential CBW agent.* The particular substance needs to be identified so that the hazard can be evaluated. This helps to ensure that scarce resources are not devoted to providing protective measures against a substance that presents little hazard.

(*b*) *Evaluation of the toxicity of this potential agent.* Such toxicity evaluation involves the extrapolation of the toxicological hazard to man and takes into account such factors as breathing rate and stress. Materials increasingly need to be evaluated for both lethality and incapacitation.

(*c*) *Potential military utility to the aggressor.* This evaluation addresses such aspects as whether the potential agent could be produced in sufficient quantity and be weaponized by the aggressor; also whether his perceived delivery means would enable the aggressor to deliver a sufficient quantity to produce harmful effects against the defender's forces. Such evaluations need to be comparative because the use of a CBW agent is only likely to be utilized by the aggressor should it enable him to achieve his particular military objectives more effectively than through the use of conventional weapons.

Any evaluation of the hazard must take into account all of those strands if a realistic assessment and evaluation is to be achieved.

Once the hazard has been assessed, effective protective measures are then based on a number of approaches:

(*a*) *The provision of advice to the Armed Services* on how their operational tactics may be modified so as to minimize the potential hazard.

(*b*) *Detection.* The provision of a range of detection and warning devices which will sense the presence or approach of a harmful concentration of CBW agent and thereby alert the Armed Forces to don their protective measures.

(*c*) *Protection.* (FIG. 3) This falls into three categories:

(*i*) *Respiratory protection.* In general, the most vulnerable part of the body is the respiratory system and the lungs. The provision of a respirator to be worn whenever a hazardous concentration of agent is in the vicinity is an effective protective measure. The S10 respirator is entering service now.

(*ii*) *Body protection.* Some CBW agents, but not all, have a percutaneous effect and harm the body through attack of the skin. Consequently, body protection is required and is provided by an NBC suit which is designed to minimize the physiological load on the body and to maximize the protection against CB agents. Most current suits are multi-layer and porous. The No. 1 Mk. 4 suit has now entered U.K. service.

(*iii*) *Collective protection.* This is the provision of protection for groups of personnel either within a protected building (i.e. hardened collective protection) or within a more temporary structure that does not provide protection against shrapnel and fragments (unhardened collective protection). In collective protection, the incoming air supply is filtered to remove any CBW agent and provision is made for airlocks for access and exit. Collective protection is provided in most ships, Armoured Fighting Vehicles (AFVs) and pilot facilities at air bases. It is also required for military medical facilities and to enable rest and relief of services personnel.

(*d*) *Contamination Monitoring.* Once protective measures have been taken, it is necessary to monitor the level of the hazard so that the protective measures such as the respirator and suit can be removed once it is safe to do so and thereby reduce the physiological stress imposed through the wearing of full protective clothing. British service personnel are equipped with the Chemical Agent Monitor (CAM) which represents

a world first in its provision of a hand-held monitoring device which enables commanders to take decisions as to when the protective posture may be relaxed.

(*e*) *Contamination Management*. Some CB agents are highly persistent and present a prolonged hazard. The disadvantages caused by such agents can be minimized through chemical hardening (i.e. the design of military equipment so as to minimize the presence of crevices and cracks into which an agent may find its way and be retained) and by decontamination using decontamination techniques.

FIG. 3—BRITISH CHEMICAL AND BIOLOGICAL DEFENCE EQUIPMENT: THE S10 RESPIRATOR, THE NO.1 MK.4 NBC SUIT AND THE CHEMICAL AGENT MONITOR (CAM)

(*f*) *Medical Countermeasures*. Medical countermeasures need to be provided for those personnel who have been exposed to a CB agent. Medical countermeasures fall into two groups:

(*i*) *Prophylaxis or Pretreatment*. This involves protecting the body in advance of any exposure to a CB agent.

(*ii*) *Therapy*. This involves treatment after exposure to a CB agent has occurred.

British forces are provided with a most effective pretreatment and treatment against nerve agents. These consist of a pyridostigmine bromide (NAPS—Nerve Agent Pretreatment Tablet Sets) which is taken three times a day, seven days a week when personnel are assessed to be under threat of attack by CBW agents, and the ComboPen, an auto injection system which is self administered by service personnel should they experience the symptoms of nerve agent poisoning.

Against the potential CBW spectrum, the thrust of current work is to provide broad band protective measures that will protect against the entire spectrum or against part thereof. Some protective measures are highly effective against a range of the spectrum whilst others are, currently, agent-specific.

Arms Control

1925 Geneva Protocol

The use of chemical weapons in World War I led to an international agreement to prohibit the use of such weapons. This was the 1925 Geneva Protocol prohibiting the use in war of asphyxiating, poisonous or other gases, and of bacteriological methods of warfare. This Protocol has now been signed by about 125 nations. Some 30 of the major nations who have signed this Protocol have done so with a reservation. For example, the United Kingdom signed with the following reservation:

(1) The said Protocol is only binding on His Britannic Majesty as regards those Powers and States which have both signed and ratified the Protocol or have finally acceded thereto.

(2) The said Protocol shall cease to be binding on His Britannic Majesty towards any Power at enmity with Him whose Armed Forces, or the Armed Forces of whose allies, fail to respect the prohibitions laid down in the Protocol.

The Geneva Protocol is therefore essentially a prohibition of first use of CBW weapons.

1972 Biological and Toxin Weapons Convention

Although bacteriological weapons were included in the 1925 Geneva Protocol, a more comprehensive treaty to prohibit the development, production and stockpiling of bacteriological (biological) and toxin weapons and their destruction was signed in London, Moscow and Washington on 10 April 1972. This is often referred to as the Biological Weapons Convention (BWC) but it explicitly includes both living microorganisms (the right-hand two boxes of the spectrum) and toxins; its correct full title is 'Convention on Biological and Toxin Weapons'.

Article I of that Convention states:

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

(1) Microbial or other biological agents, or toxins, whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protection or other peaceful purposes;

(2) Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

There is no definition of what is intended by microbial or other biological agents nor is there a definition of toxins. Furthermore, whilst nations have all agreed not to develop, produce, stockpile or otherwise acquire to retain such agents or weapons designed to use such agents, there is no prohibition of possession of a production capability. Whilst possession of BW would be a breach of the Convention, the possession of dual purpose weapons,

equipment or means of delivery would not. Nor are there provisions for intrusive verification and monitoring of compliance.

Over 110 nations are now party to the Biological and Toxin Weapons Convention. An Article of the Convention requires that five years after the entering into force of the Convention, a conference of States Parties shall be held at Geneva, Switzerland, to review the operation of the Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention are being realized. Such reviews should take into account any new scientific and technological development relevant to the Convention.

Such Review Conferences were held in 1980 and 1986 and the next is likely to take place in 1991. The first Review Conference in 1980 occurred at the same time as information became available in the West about the outbreak of anthrax at Sverdlovsk in Russia. In that outbreak, significant numbers of people died from anthrax which was alleged to have resulted from the release of anthrax organisms from a secret facility in the Sverdlovsk area. This issue has yet to be satisfactorily resolved as the Soviet Union states that the outbreak of anthrax was due to the eating of contaminated meat, a claim that does not satisfy Western concerns. The 1986 Biological Weapons Review Conference took note of the advances in genetic engineering over the past decade and agreed on four voluntary confidence-building measures:

(*a*) Declaration of all Category 4 laboratories and MOD Category 3 laboratories.

(*b*) Declaration of unusual outbreaks of disease.

(*c*) Encouragement of publication of work.

(*d*) Encouragement of international conferences.

Nations agreed that they should make these voluntary returns on an annual basis. It is regretted that thus far less than one quarter of the signatories to the Biological Weapons Convention have made such returns. The next Review Conference will assess the value of these confidence-building measures and seek ways to encourage a wider response from States Parties.

Chemical Weapons Convention

Negotiations have been in progress at the Conference on Disarmament in Geneva towards a Chemical Weapons Convention which would be a comprehensive, verifiable and global ban on chemical weapons. The multilateral negotiations at Geneva involving some forty States together with a number of observers, have resulted in over 100 pages of rolling text. Good progress has been made towards the agreement of a Chemical Weapons Convention although significant technical problems have yet to be resolved. The United Kingdom has played a leading role in these negotiations in Geneva and is seeking to ensure that the eventual Chemical Weapons Convention will enhance the security of all States. The current rolling text comprises a number of Articles which include:

Article II Definitions and criteria

Article III Declarations

Article IV Chemical Weapons

Article V Chemical Weapons production facilities

Article VI Activities not prohibited by the Convention

Article IX Consultations, cooperation and fact finding.

Article II defines the scope of chemical weapons with the following words:

> The term 'chemical weapons' shall apply to the following, together or separately:
>
> (*i*) toxic chemicals, including super-toxic lethal chemicals, other lethal chemicals, other harmful chemicals and their precursors, including key precursors [and key components of binary and/or multicomponent chemical systems for chemical weapons], except such chemicals intended for purposes not prohibited by the Convention as long as the types and quantities involved are consistent with such purposes;
>
> (*ii*) munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals, as referred to above, which would be released as a result of the employment of such munitions and devices;

It is thus clear that all toxic chemicals, lethal chemicals and harmful chemicals are covered *except* such chemicals intended for purposes not prohibited by the Convention.

Articles III, IV and V all relate to the declaration of existing stockpiles of chemical weapons and of chemical weapon production facilities together with the arrangements for destruction of such chemical weapons and chemical weapon production facilities. Articles VI is a particularly important Article which seeks to discriminate between the use of chemicals for civil purposes which are *not* prohibited by the Convention and their potential use for chemical weapons. This Article currently consists of three schedules of chemicals together with associated inspection regimes. Article IX includes provision for challenge inspection on request at short notice.

FIG. 4—REPRESENTATIVES FROM THE SOVIET UNION OBSERVED U.K. CBD EQUIPMENT AT CDE PORTON DOWN IN MAY 1988

The overall aim of the Chemical Weapons Convention is to deter any nation from seeking to acquire a chemical weapons capability by ensuring that the inspection regimes are sufficiently intrusive that the nations will judge that they will be unable to conceal a covert CW capability. A particular

problem is how to differentiate effectively between toxic chemicals that are required for civil industry and those which might be used for a CW capability. It is, however, apparent that an essential element in deterring the use of chemical weapons subsequent to a Chemical Weapons Convention will be the maintenance of effective protective measures against CBW. This arises from the fact that the range of toxic chemicals which can be used against unprotected personnel is extremely wide and is much wider than the range that might be used against protected troops. In effect, in putting the genie of chemical weapons back into the bottle, we recognize that the walls of the bottle will become thinner in the future unless nations retain effective protective measures and thereby reduce the potential advantages to a nation contemplating breakout from a Chemical Weapons Convention.

Soviet-U.K. Exchange Visits

In 1988, exchange visits were held between the Soviet Union and the United Kingdom. A party of thirteen representatives from the Soviet Union visited the Chemical Defence Establishment at Porton Down for three days (FIG. 4). Subsequently, thirteen representatives from the United Kingdom visited the Soviet Chemical Weapons Facility at Shikhany some 1000 km south-east of Moscow and a Soviet Chemical Troops training facility 60 km east of Moscow. (FIGS. 5 and 6). The aim of these exchange visits was to build confidence between the U.K. and the Soviet Union and thereby foster the negotiations at Geneva.

FIG. 5—REPRESENTATIVES FROM THE U.K. VISITED A SOVIET UNION CHEMICAL TROOPS TRAINING CENTRE AT BUNKHOVA, 60 KM EAST OF MOSCOW, IN JUNE 1988 AND WERE SHOWN A TMS-65 DECONTAMINATION SYSTEM

In the visit to CDE Porton Down, a wide range of CW-related topics was addressed which included production, storage, trials, assessment of the hazard, delivery means, detection, protection, monitoring, decontamination, medical countermeasures and disposal. At the end of the visit to CDE, the Soviet Union representatives stated at the Press Conference that they were pleased with the openness that the U.K. had shown and undertook to reciprocate on the return visit. However, on the return visit to Shikhany, it became apparent that the Soviet Union's perceptions of openness were very

different from those of the U.K. and the Soviet Union still had a long way to go in this respect. In particular, on the visit to the Chemical Defence Establishment at Porton Down, the Soviet Union representatives were given a helicopter overflight of the entire area and invited to choose any points to visit and chose four such places. In the return visit, the helicopter overflight was limited to the range at Shikhany and although we were able to visit ten locations, visits to a related facility and to a storage area were refused (FIG. 7).

Confidence remains to be built in relation to Soviet public statements about their chemical weapons capability but, since the CDE/Shikhany exchange of visits, there has been significant progress in U.S./Soviet bilateral consultations on chemical weapons which include a bilateral Memorandum of Understanding (signed in Wyoming in September 1989) providing for a two-phase experiment in data exchange and verification. In February 1990 the U.S. and Soviet Union agreed in principle to destroy their respective chemical weapons stocks down to 20% of existing U.S. levels in advance of a multilateral Chemical Weapons Convention.

FIG. 6—SOVIET CHEMICAL TROOPS IN FULL PROTECTIVE EQUIPMENT, BUNKHOVA, JUNE 1988

The Way Ahead

Two quotations from Soviet representatives in *The Christian Science Monitor* articles[4] of 1988 on the subject of chemical and biological warfare are particularly interesting. The first is a statement made in 1987 by Valentin Falin, then Head of the U.S.S.R. Novosti Press Agency, who was talking in the United States about Moscow's response to new U.S. space based weapons systems when he said:

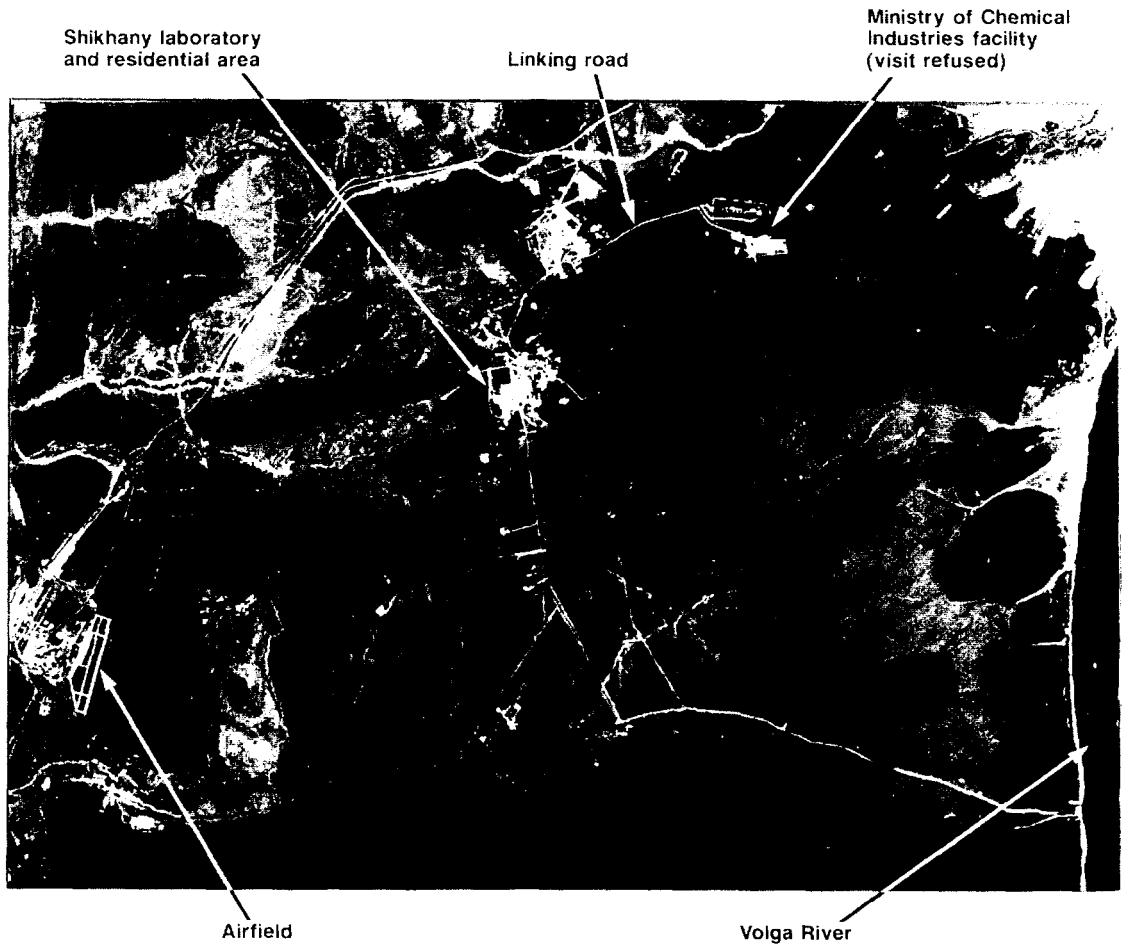


FIG. 7—LANDSAT PHOTOGRAPH OF THE SHIKHANY CW FACILITY, 1000 KM SOUTH-EAST OF MOSCOW

> We won't copy you anymore, making planes to catch up with your planes, missiles to catch up with your missiles. We will take asymmetrical means with new scientific principles available to us. Genetic engineering could be a hypothetical example. Things can be done for which neither side could find defences or countermeasures with very dangerous results. These are not just words. I know what I am saying.

The second quotation from the same series of articles is from Nikita Smidovitch, a Soviet diplomat in the Ministry of Foreign Affairs, who said:

> But my scientists have told me that we have no more than five years before the life sciences make a breakthrough, and we have a whole new line of agents.

It seems incredible that the Soviet Union has not developed any new agents beyond those that were known in the early 1950s and which were developed in the West.

In addition to the Warsaw Pact CBW capability, the number of nations which either possess a CBW capability or are actively seeking to acquire one is now reported to be in excess of twenty (FIG. 8). It is also becoming evident that nations are not limiting themselves to the classical CW agents which require purpose-built plants but are turning their attention to other toxic chemicals which may be produced in civil chemical plants either as products or by-products. In addition, it is known that Iraq and Iran have recently sought to obtain samples of anthrax and fungi strains from the West.

The way forward to provide effective protective measures for the U.K. Armed Forces is through the provision of broad-band defensive measures which are effective against a wide range of agents across the spectrum. In addition, continued efforts are needed to achieve an effective verifiable,

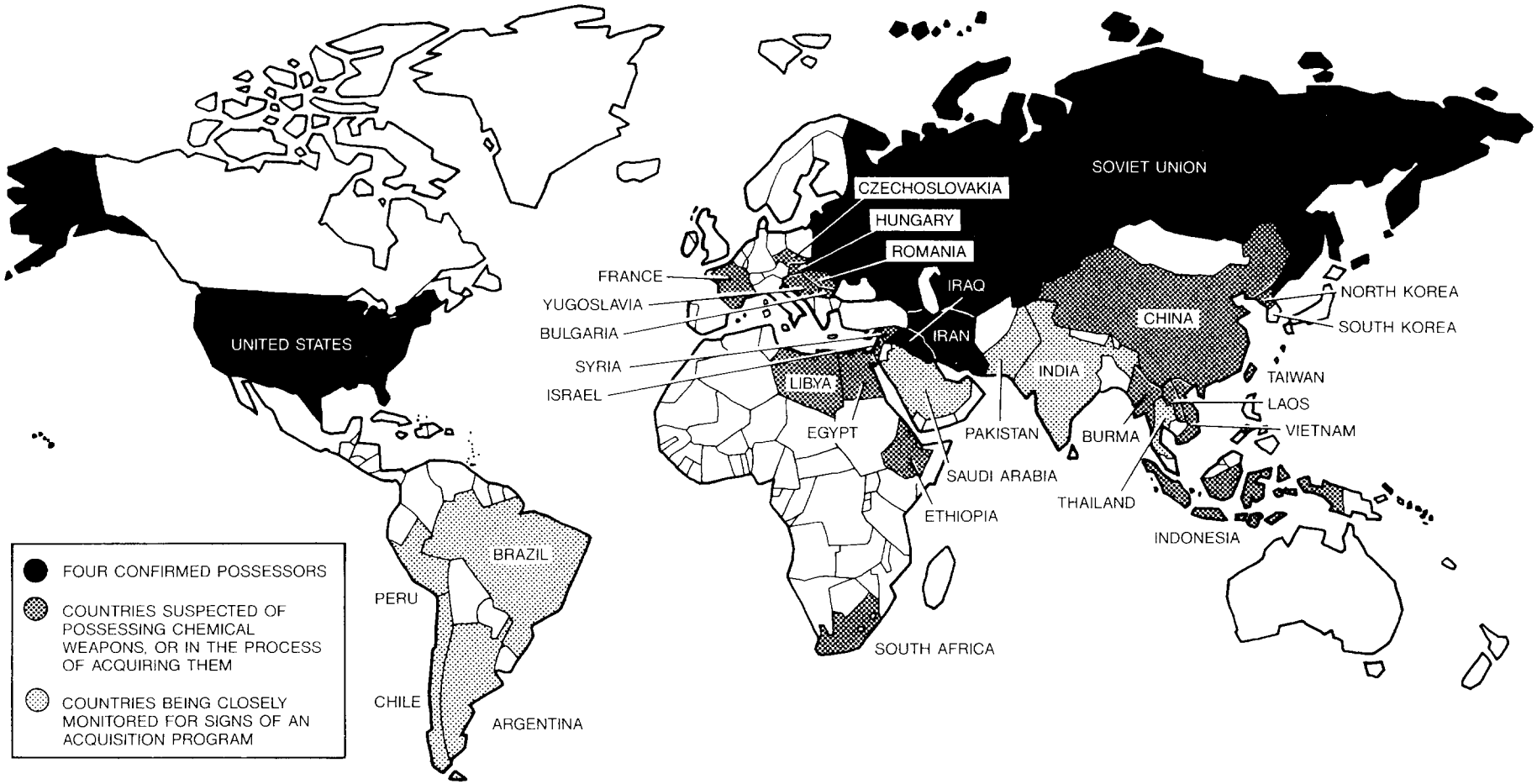


FIG. 8—CHEMICAL WEAPONS PROLIFERATION: THE CHEMICAL WEAPONS CLUB (BASED ON A MAP PUBLISHED IN DECEMBER 1988[4])

comprehensive and global ban on chemical weapons that will deter any nation from acquiring such a capability. Once such a Convention has been achieved that addresses all non-living chemicals up to and including the bioregulators and toxins, the thrust should then be on arriving at an equally comprehensive and intrusive regime for biological weapons.

Finally, it is essential to recognize that strong defence against the threat of CBW will be needed even after a Chemical Weapons Convention and an improved Biological Weapons Convention have been agreed. If those defences are not maintained and are not strong, the temptations to a nation to breach the Convention could be very high because of the immense advantage that it could perceive would accrue through its use of chemical or biological warfare. Many of the productive measures such as detection, identification, protection, diagnosis, prophylaxis and therapy which arise from defence work are equally applicable to civil applications in protection against toxic materials: this spin-off represents a considerable bonus.

References

1. *Hansard*, 10 May 1988, col. 105.
2. United States Army, Medical Department: *General medicine and infectious disease*; Washington, Office of the Surgeon General and Center of Military History, U.S. Army, 1982. [Internal medicine in Vietnam, vol. 2.]
3. Krauze, N. and Nowak, I.: *Modern chemical troops*; Warsaw, Publishing House of the Ministry of National Defence, 1983.
4. Thatcher, G.: *The Christian Science Monitor*, 13–16 Dec. 1988 (republished as a Christian Science Monitor Special Report, *Poison on the wind*, [1988]).