Soviet Biological Warfare Threat

Defense Intelligence Agency

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This document represents the Defense Intelligence Agency's continuing effort to respond to requests from members of Congress, the Armed Forces and the public for unclassified information on the Soviet Union's biological warfare (BW)[1] capabilities.

The illustrations in this document are derived from various U.S. sources; while not revealing of every detail, they are authentic.

The United States Government has not recognized the incorporation of Estonia, Latvia and Lithuania into the Soviet Union. Other boundary representations on the maps are not necessarily authoritative.

Cover Illustration:
Soviet helicopters, such as the Mi-24/HINDs depicted, are capable of disseminating aerosols of biological warfare agents.

[1] This booklet focuses on the threat from Soviet disease agents developed for BW purposes and does not elaborate the threat from Soviet toxin weapons

Soviet Biological Warfare Threat

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Prepared by the Defense Intelligence Agency

Soviet maintenance of an offensive biological warfare program and capability, as well as their involvement in the production and transfer of toxins to surrogates in Southeast Asia, are in violation of the Biological and Toxin Weapons Convention. Their use of chemical and toxic substances for hostile purposes in Southeast Asia and Afghanistan is a violation of The 1925 Geneva Protocol. For details see:

— U.S. Department of State Special Report No. 98 — *Chemical Warfare in Southeast Asia and Afghanistan,* March 22, 1982.

— U.S. Department of State Special Report No. 104 — *Chemical Warfare in Southeast Asia and Afghanistan: An Update,* November 1982.

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Committed to Excellence in Defense of the Nation.

FOREWORD

It is the purpose of this booklet to provide a better understanding of the nature of biological weapons and the impact of evolving technologies on the development of biological warfare (BW). The nature of disease research, wherein research for peaceful or military purposes is virtually indistinguishable, makes it extremely difficult to identify non-compliance with the Biological and Toxin Weapons Convention of 1972. For example — virulence, infective dose, aerosol behavior, immunizing characteristics and production economy studies that are done for medical, biological and public health research are also relevant to developing a disease agent for warfare purposes.

Some infectious disease and toxin research and development can always give rise to ambiguities and suspicions. However, the major accident that occurred in the Soviet Union in the city of Sverdlovsk in April 1979 raised concerns that anthrax agent was under investigation at a level beyond what is allowed by the Biological and Toxin Weapons Convention. Indeed, Soviet BW-related activities since World War II lead us to conclude that they have developed and produced biological and toxin agents and the associated hardware for use as BW weapons.

In recent years, we have become increasingly concerned that this genre of weaponry will be developed by some nations including those of the Third World. We are gravely concerned that we will see BW programs underway in some countries within five years and limited production within a decade.

We have also provided a number of appendices for background information. These include the peaceful and weapons implications of biotechnology, the complete texts and listings of signatory nations for the Biological and Toxin Weapons Convention of 1972 and the Geneva Protocol of 1925, and descriptions of how BW agents and munitions can be safely destroyed.

LEONARD H. PERROOTS
Lieutenant General, USAF
Director

Soviet Biological Warfare Threat

KEY JUDGMENTS

The Biological and Toxin Weapons Convention of 1972 prohibits the development, production and stockpiling of biological and toxin weapons. In effect, the Geneva Protocol of 1925 prohibits the first use of chemical and bacteriological weapons in war. (See appendices for the complete texts of the Convention and Protocol.) We believe that the Soviets have gone far beyond what is allowed by these treaties for the following reasons:

- The size and scope of their efforts are not consistent with any reasonable standard of what could be justified on the basis of prophylactic, protective or peaceful purposes.
- The Soviets continue to evaluate the military utility of biological and toxin weapons.
- The Soviets are rapidly incorporating biotechnological developments into their offensive BW program to improve agent utility on the tactical battlefield.

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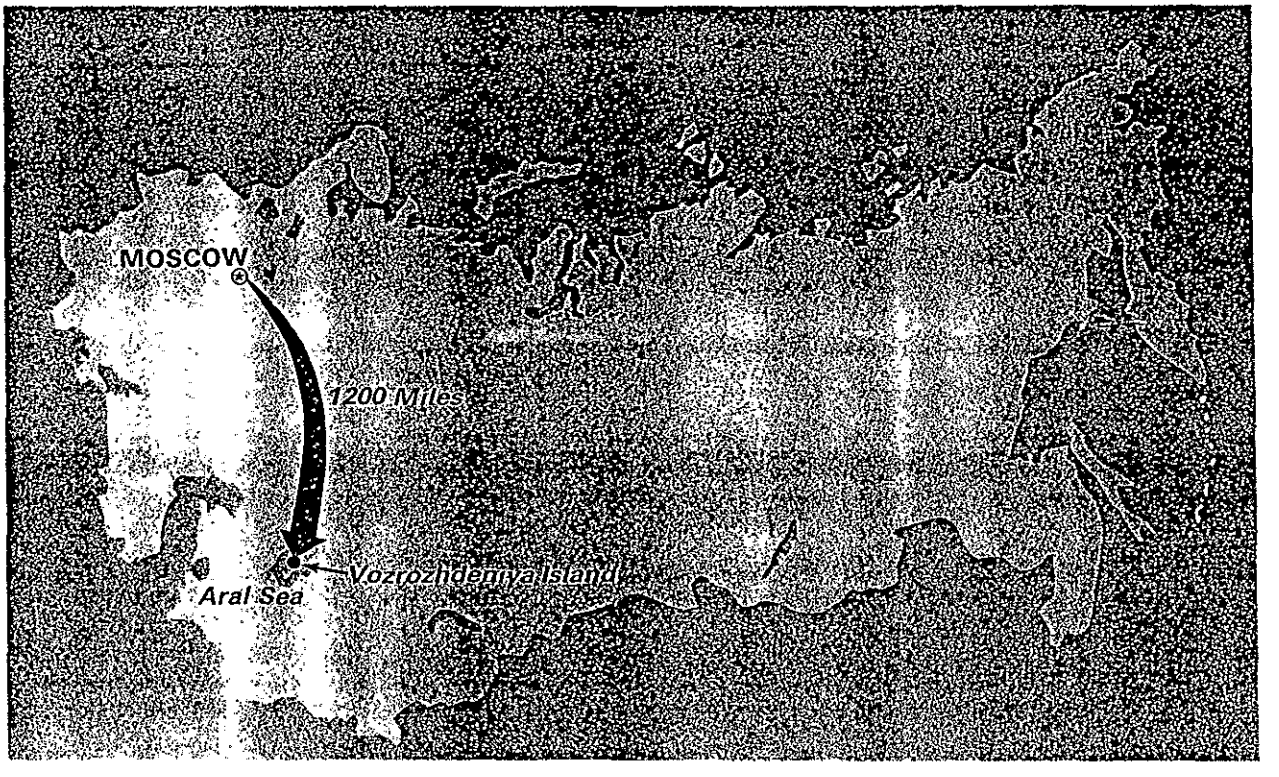
The Soviet Biological Warfare Capability

The Soviet offensive BW program has been monitored by the U.S. for decades. When the Biological and Toxin Weapons Convention (BWC) of 1972 went into force in 1975, the issue became one of whether or not the Soviets were in compliance. Although the BWC bans the development, production and stockpiling of biological agents and toxins for hostile purposes, we have observed no reduction in Soviet offensive BW activity. We have concluded that the Soviets have and are developing and producing BW agents. They are continuing to test and evaluate delivery and dissemination systems for these agents.

Scientific personnel at a number of Soviet microbiological research institutes are capable of performing research and development (R&D) with highly infectious disease agents and very potent plant, animal and microbial toxins. Likewise there is considerable Soviet work in aerobiology, cloud physics, airborne infections, and disease agent stabilization which has direct application to BW. Much of the knowledge and technical expertise at these institutes is funded and utilized by the Soviet Ministry of Defense for offensive BW as well as for defensive/protective aspects.

We also have identified a number of installations capable of producing disease agents and toxins on a large-scale and placing them in muni-



Location of the candidate BW test and evaluation installation on Vozrozhdeniya Island in the Aral Sea.

tions and delivery/dissemination systems. These installations have been established by the Ministry of Defense and are under its control. One such facility is in the city of Sverdlovsk and has a long history of biological warfare R&D and production with emphasis on the causative agent of anthrax. In addition to anthrax, we believe the Soviets have developed tularemia, plague and cholera for BW purposes, as well as botulinum toxin, enterotoxin, and mycotoxins.

Biological Warfare Agent Production

The production of large quantities of disease agents by the Soviets for BW purposes can be accomplished by various fermentation processes. In a strict sense industrial fermentation processes are concerned with the products produced by multiplying microorganisms. However, a fermentation process can also be used to produce large numbers of microorganisms which themselves become the desired end-product. Thus, an infectious agent grown in large numbers and then placed in a weapon/dissemination system becomes a BW weapon. Production of a toxin agent is usually accomplished using fermentation processes except that the toxin produced by the microorganisms during the growth process is the end-product rather than the microorganism itself. A viral or rickettsial agent, unlike a bacterial agent, requires living metabolizing animal cells for growth, thereby requiring large-scale use of embryonated eggs or tissue cell culture systems to produce quantities of viruses or rickettsia for BW weapons.

Shown is an illustration of a batch fermentation system for bacterial agents which depicts the pro-

cess from starter, or seed culture, to end-product for use in munitions or other dissemination devices. Continuous fermentation can also be used for BW agent production. The anthrax agent can be produced from start to finish in 96 hours since bacteria have the ability to multiply very quickly as illustrated in the table. Both systems can be computer controlled.

During the growth cycle of anthrax, the microorganism is in the shape of a rod, its vegetative form. Towards the end of its growth cycle, it can be made to convert into spores by heat or chemical shock. It is the spores that are harvested and placed into delivery/dissemination devices. The spores are very resistant to heat, disinfectants, sunlight and other environmental factors. When the spores are inhaled, they convert again to the vegetative form, establish an infection, and as they multiply in the host, produce a highly lethal toxin. Anthrax causes a high mortality rate when the infection results from ingestion (up to 70 percent fatal) or inhalation (almost 100

Number of hours	Number of bacteria
0	1
1	8
2	64
3	512
4	4,096
5	32,768
6	262,144
7	2,097,152
8	16,777,216
9	134,000,000
10	1,072,000,000

The multiplication of the bacterium,* Escherichia coli, *under ideal growth conditions. Many bacteria have generation times like those of* E. Coli. *One can readily see the heavy concentration of bacteria that will result during growth cycles in liquid cultures. New computerized systems are increasing these concentrations of bacteria per unit volume.

percent fatal) if treatment is not begun promptly. Although anthrax bacteria are penicillin sensitive, successful treatment of the disease depends upon killing the microorganisms before a lethal concentration of anthrax toxin is produced. The skin form of infection can also be lethal if it invades the bloodstream and therapy is not started quickly. In addition to penicillin, other antibiotics are effective.

Anthrax spores can be disseminated in either a liquid or dry form. Although highly resistant in the environment, they can be killed with strong disinfectants or high temperature. Anthrax is a non-contagious agent. The number of anthrax spores required to kill 50 percent of exposed individuals (lethal dose 50 or LD50) is between 8,000 and 10,000. Even though such high concentrations of anthrax are required to be delivered over a target population, the Soviets have no technical difficulties in achieving this. Having produced BW agents they must also be concerned with their destruction. See Appendix D.

The Sverdlovsk Biological Warfare Facility: The Events of 1979

During early April 1979, an accidental release of anthrax occurred in Sverdlovsk that caused many casualties and most probably a very high death rate among Soviet citizens who were exposed. The Soviet Government at that time admitted only to some public health problems, which it said were caused by the illegal sale of anthrax-contaminated meat. They have never acknowledged the existence of the Sverdlovsk facility and, of course, have never revealed the nature of the work conducted there. The U.S. Government has requested an explanation of what happened in Sverdlovsk on numerous occasions but the Soviets persist in blaming contaminated meat for the anthrax epidemic.

Our analysis shows that the following events occurred:

- Early in April 1979, an accidental release of anthrax occurred within the Microbiology and Virology Institute in Sverdlovsk City. The Institute is a military facility located in the southwestern outskirts of the city. While bulk quantities of anthrax spores in dry form were probably being prepared, a pressurized system probably exploded.

- As much as 22 pounds (10 kg) of dry anthrax spores were released from the Institute.

- The bacterial aerosol contaminated an area with a radius of at least 2-3 miles.

- Within two weeks, which is within the time frame expected for the disease to develop, a significant number of deaths occurred.

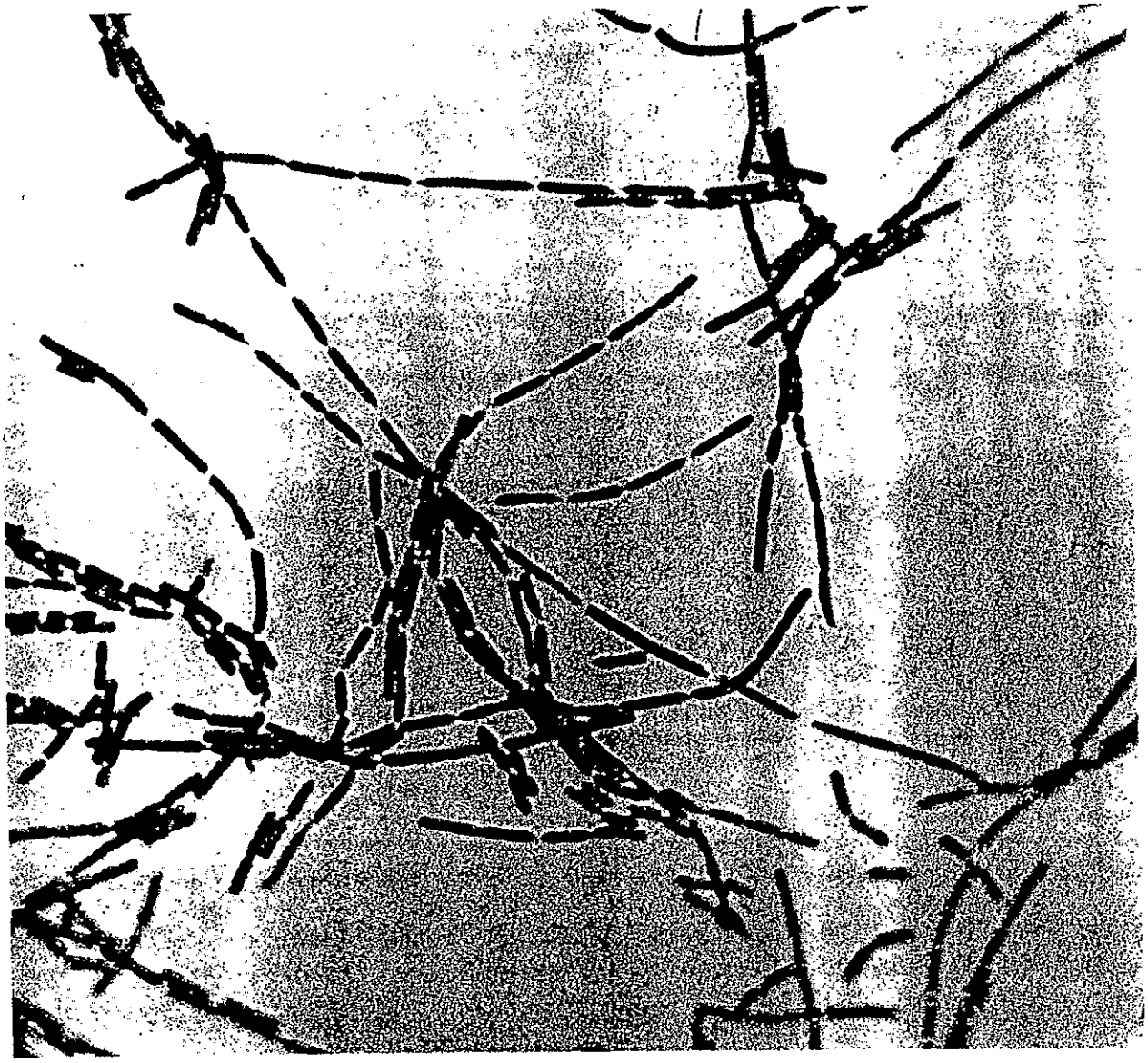
- Residents and workers within the contaminated area contracted pulmonary anthrax through inhalation. In addition it is possible that some may have contracted anthrax by skin contact and, over time, a number may have contracted anthrax by consumption of food contaminated by the fall-out of spores.

- Initial disinfection and decontamination procedures were largely ineffective.

- Mass immunizations with the Soviet anthrax vaccine were partially effective at best.

	Accident Potential	Aerosol Release
Lab Operations	Low-Medium	mg-g
Pilot Plant Scale	Low-High	g-KG
Production	Medium-High	50g-300 KG
Training	Medium	up to 5KG
Testing	High	up to 100g
Storage	Low	up to 100KG
Waste Handling/ Decontamination	Low	g

Each of the various operations involved in the production of anthrax has the potential for releasing aerosols in quantities indicated (one thousandth of a gram to 300 kilograms). The scale of operations, whether the agent is in liquid or dry form, and whether the operations involve high pressure, volatile solvents, or explosives also affects the potential for aerosol release. It is difficult to aerosolize more than 10% of wet anthrax spores. It is relatively easy to aerosolize almost 100% of anthrax spores in dry form. These factors plus other information were critical in our analysis of the Sverdlovsk accident.



An 18-hour culture of anthrax.

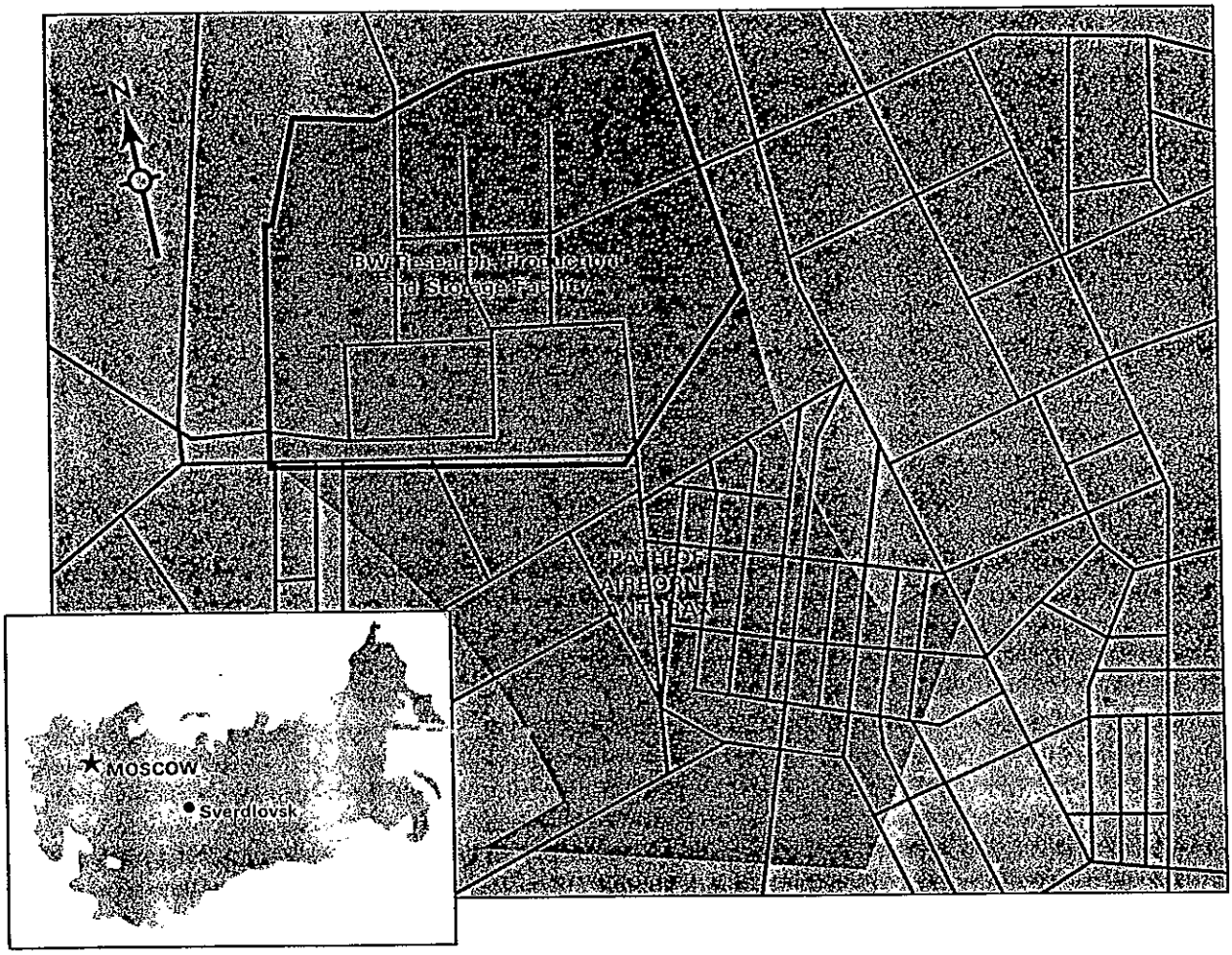
- Vaccinations and antibiotic treatment were administered too late as an initial response.
- Containment procedures were effective in confining the problem to the southwest area of Sverdlovsk City.
- Strict censorship as to the true nature of the incident served to neutralize early panic and limit the fears of the Sverdlovsk population.
- Containment procedures continued into July 1979. Some inspection procedures were conducted until the Fall of 1979.

In summary:

- A major outbreak of anthrax occurred at a closed military installation.
- The Soviets have persisted in claiming that a routine outbreak of anthrax among animals caused intestinal anthrax among people who consumed the bad meat.
- The extraordinary efforts to "clean-up" are inconsistent with the Soviet explanation.
- It has been reported that hundreds of Soviet citizens died from inhalation anthrax within

seven to ten days of the outbreak despite heroic attempts by Soviet doctors to save their lives.

- It has also been reported that in subsequent weeks there may have been 1,000 or more cases. These figures are about 100 or more times the annual incidence of inhalation and intestinal anthrax throughout the USSR in recent years.[1]
- Heavy military involvement and early military casualties immediately after the accident, total military control within two weeks, plus roof top spraying of decontaminating solutions from aircraft are not consistent with public health control measures for dealing with anthrax acquired by eating bad meat.
- The reported aerial spraying activity and disinfection with steam and hypochlorite solution around the military facility are clear attempts to decontaminate surfaces affected by an infectious aerosol.



Accidental release of anthrax from Biological Warfare Facility at Sverdlovsk.

[1] In the USSR the usual incidence of clinical anthrax in humans has been approximately 95 percent cutaneous (skin), 2.4 percent intestinal, 1.2 percent inhalation, and 1.4 percent other forms. Based on Soviet data, the estimated total number of cases in the USSR during 1978 was about 700 for all forms of anthrax. This translates to seventeen expected intestinal cases and eight expected inhalation cases. The 1978 incidence of anthrax is similar to that for the period 1965-78.

- Collectively, these events are a very strong contradiction of the Soviet position which claimed the anthrax outbreak was just a public health problem resulting from the sale of contaminated meat.

The Soviet Biological Warfare Organization

Regular Soviet Chemical Troops of the Ministry of Defense are involved in BW activities. Despite the name Chemical Troops, this force is responsible for ensuring that Soviet units can operate under any type of contaminated battlefield including nuclear, biological and chemical (NBC). This force has some 45,000 officers and soldiers in the ground forces alone in peacetime. They man special NBC reconnaissance and decontamination units which are part of ground force formations at all levels from regiment to *front*. Similar units exist in the other branches of service.

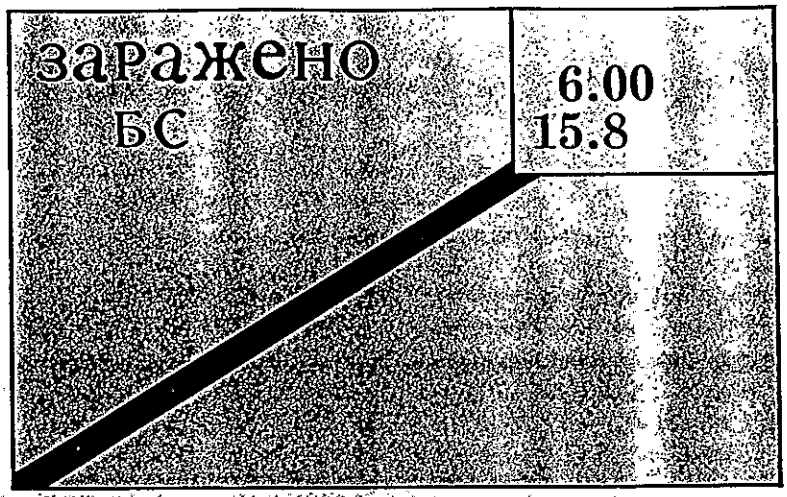
The responsibilities of the Chemical Troops include oversight of:

- Development of biological and chemical weapons.
- Testing and evaluation of BW and chemical warfare (CW) agents and delivery/ dissemination systems.
- Weaponizing and storage of BW and CW agents.
- Technical advice to combat commanders regarding the use of and effectiveness of biological weapons.
- R&D, production and storage of protective gear.
- Training of all forces for survival on a battlefield contaminated with BW agents.
- Reconnaissance and decontamination.
- Operating the Chemical Academies (college equivalent).

New Soviet Chemical, Biological, Radiological Protective Mask.

The specialists of the Chemical Troops have over 30,000 vehicles specifically designed for NBC reconnaissance and decontamination of personnel and equipment. Special training areas exist for training units of the Chemical Troops. Additionally, most modern Soviet vehicles have collective protection systems designed to protect against NBC contamination.

The Soviets have vaccines or antidotes for many of the diseases that they might use in a BW attack. These include those for anthrax, tularemia, plague, and botulism. Immunization is essential for those personnel who produce, handle, and deliver BW agents and weapons as well as those who would move into an area where BW agents had been disseminated. Standard Soviet protective suits and masks, together with sanitary and disease control measures, would be sufficient to protect most Soviet soldiers from the effects of their BW agents.



BW warning flag and marker for identifying terrain contaminated by disease agents and toxins.

Biotechnology and the Soviet Union

The Soviet Union has been combating and controlling disease epidemics for many years. As a result, they have developed expertise in biomedical research, identifying the foci of infections and controlling diseases. They have made significant contributions to the literature on infectious diseases and have had an impact in the international arena on public health matters. Their knowledge of the behavior of bacteria, viruses and rickettsia is voluminous and has been used primarily to address domestic and international problems of disease control.

The Soviets also have had a long-standing interest in industrial biotechnology which dates back to World War II. During the siege of Leningrad single-cell protein (SCP) derived from wood shavings was used as food. Since that time, the Soviet SCP industry has grown to be the largest in the world with over a million tons produced annually and used for livestock fodder. It is estimated that one ton of SCP frees up about six tons of feed grain that otherwise would have to be imported and paid for in hard currency. The Soviets are also dependent upon their microbiological industry to produce vitamins, antibiotics, vaccines and advanced diagnostics and therapeutics for legitimate use in their military and civilian populations.

The Soviets now recognize the potential of modern biotechnology and genetic engineering particularly since the Soviet Union has a greater need for advancements in agriculture and public health than the West. As such, the Soviets made the development of a biotechnological industry a top priority in 1974 and reaffirmed their commitment in 1981. Since that time, they have made remarkable progress in developing their biotechnological capabilities.

Unfortunately, these same technologies are being used by the Ministry of Defense to develop new and more effective BW agents. With this biotechnological capability, naturally-occurring microorganisms can be made more virulent, antibiotic-resistant, and manipulated to render current U.S. vaccines ineffective. Such developments would greatly complicate our ability to detect and identify BW agents, and to operate in areas contaminated by the Soviets with such biological agents. See Appendix A for a comprehensive review of the various aspects of biotechnology.

APPENDIX A

BIOTECHNOLOGY: PAST, PRESENT AND FUTURE

BIOTECHNOLOGY

Introduction

Biotechnology is a very broad field which involves many disciplines within science and industry. Currently basic sciences such as genetics, molecular biology, chemistry, biochemistry, microbiology, immunology, pharmacology, and toxicology are primarily used for the research and development of products. Primary emphasis is being directed towards diagnostic and therapeutic aids for medicine. In both the short- and long-term, more scientific disciplines such as engineering, agriculture, computer technology, animal husbandry, structural technology and geology will become participants in the worldwide biotechnological effort. The potential of biotechnology for the benefit of both the developed and lesser developed areas of the world is tremendous. Unfortunately, the Soviets are not only taking advantage of the beneficial aspects but are simultaneously exploiting biotechnology for the development of new biological warfare agents.

History of Biotechnology

Biotechnology is not a new field of science. In one way or another humans have practiced biotechnology from the time wine was first made, foods were preserved, and plants were domesticated and selected for their biggest and best crops. This early type of biotechnology occurred by chance. One can imagine the surprise experienced by the first person who waited too long to drink grape juice which had unknowingly been fermented to wine by yeast. The same wine, if stored even longer, became vinegar due to bacteria which converted the alcohol to acetic acid. Through the centuries, chance occurrences and need, accompanied by common sense, developed into industries which have given mankind foods, such as wine, beer and cheese; the pickling process and other types of food preservation; many agricultural plants; and numerous antibiotics and drugs.

The discovery of penicillin by Fleming in 1929 was by chance. A spore of the fungus, *Penicillium notatum,* contaminated a petri dish containing the bacterium, *Staphylococcus aureus,* which is a human pathogen (disease causing). Fleming noticed that *Staphylococcus aureus* did not grow in the vicinity of where the fungus was growing. Fleming correctly interpreted this to mean that the fungus was producing something which inhibited bacterial growth. This compound was penicillin which is now known to interfere with cell wall synthesis and thereby kill the bacteria. The amount of penicillin produced by Fleming's strain of *Penicillium,* however, was very small. It took many years of experimentation and selection before high yields of the antibiotic could be produced on an industrial scale. Fortunately, large amounts of penicillin were available during World War II and many thousands of lives were saved. Following the discovery of penicillin, many more antibiotics have been and still are being discovered but in an organized fashion. It's important to keep in mind that at the time of Fleming's discovery microbiology was still in its infancy. How microbial cells operated was poorly understood even though it was recognized that microbes could be devastating when they caused disease, but beneficial when they produced foods or antibiotics. Genetics at this time was studied but the exact nature of the genetic material of cells was still being debated.

Genetics: The Foundation of Biotechnology

In 1944 the genetic material of all cells was shown to be DNA (deoxyribonucleic acid). It took almost ten more years for Watson and Crick to determine the double helical structure of DNA which contains the genetic code. Since that time, there has been an explosion in knowledge which has developed into the field of molecular genetics. It has been found that there are only four bases (adenine, thymine, guanine and cytosine) in DNA, and that these bases make up nucleotides when attached to a sugar (ribose) and phosphate groups. The sequence of nucleotides makes up genes, and genes make up chromosomes.

In the double-stranded DNA molecule, adenine always pairs up with thymine and guanine with cytosine. A spiral staircase is a good way of envisioning the structure of DNA. The boards on either side of the steps would represent the sugar-phosphate backbone, whereas the steps would be analogous to the bases (one from each side) pairing at the mid-point of the steps. It is the sequence of the nucleotides in DNA which determines if an organism is plant, animal or microbial. A typical microbial cell, for example, contains about 3,000 genes comprised of some 3 million nucleotides, whereas a human cell has around 30,000 genes and 3 billion nucleotides. The enzymatic machinery of all cells permits the DNA to be transcribed into RNA (ribonucleic acid) which in turn is translated into proteins. Proteins either become structural components of a cell or enzymes. The enzymes are responsible for millions of chemical reactions in cells which enable them to grow and to multiply.

Modern Biotechnology

Modern biotechnology is distinguished from early biotechnology by the degree to which genes can now be identified and manipulated. The roots of modern biotechnology date back only to 1973 when, for the first time, a gene was removed from the DNA of one type of cell and spliced into the DNA of another type of cell. This procedure has come to be known as recombinant DNA technology, or genetic engineering, which is graphically shown. Although a large number of technological breakthroughs was necessary to achieve what is shown in the graphic, one of the more notable was the discovery of classes of enzymes called restriction endonucleases and ligases. Restriction endonucleases permit researchers to "cut" DNA chemically at very precise locations, whereas ligases allow pieces of DNA to be rejoined chemically. The former may be thought of as "chemical scissors" and the latter, a "glue".

The identification of plasmids was yet another important discovery since these relatively small, circular pieces of DNA found naturally in many microbial cells can be recombined with genes isolated from either plants, animals or other microbial cells. They can then be introduced into microbial cells which function as biological factories for the product coded for by the gene. When plasmids contain a foreign gene and are used to transfer the gene to a foreign organism, they are called vectors. Plasmids containing foreign genes are not always inserted into microbes. They can be introduced into plant and animal cells as well.

In addition to the above molecular tools, scientists now have sophisticated instruments available for determining the nucleotide sequences of genes and the ability to synthesize genes. These instruments in a matter of days permit genetic manipulations which ten years ago took months or even years to accomplish.

Within the past several years, the field of protein engineering has emerged. In the future it will be an essential component of biotechnology. The goal here is to design proteins, such as enzymes, which are improvements over what nature has to offer. Computer simulations are and will be ever more helpful to scientists in predicting what can be achieved by changing the sequence of amino acids, the building blocks of proteins. One such enzyme is subtilisin which is used in laundry detergents.

A discussion of modern biotechnology would not be complete without mention of monoclonal

antibodies. They are produced by first immunizing an animal with an antigen, and then recovering and identifying certain white blood cells, called B-lymphocytes, which produce antibody to a single antigen. The antibody-producing lymphocytes are physically fused with cancer cells giving a hybridoma cell. The hybridoma obtains the ability to produce antibody to only one type of antigen from the lymphocyte, whereas the cancer cell gives the hybridoma immortality in tissue culture. Monoclonal antibodies can be recovered in good yield and with relative ease from the culture medium of the hybridomas.

Global Biotechnology: Who will benefit?

There is a considerable commercial Free World biotechnological effort which is being matched by universities and government research institutes. Even though biotechnology will have a great impact upon many sectors within the West and Japan, lesser developed countries along with the Soviet Union and China have the most to gain in agriculture and public health. The Soviets and Chinese recognize this and are developing governmental-directed biotechnology programs.

The Commercialization and Future of Biotechnology

Currently there are about 1800 biotechnology companies in the Free World. Most are concentrated in the U.S., Canada, Western Europe and Japan. Research is primarily directed toward developing new and better methods of diagnosing and treating disease. Considerable effort is also being devoted to: generating fuels from biomass; producing single-cell protein for livestock; developing better plants for agriculture; synthesizing chemicals on an industrial scale; treating domestic and industrial waste; creating new structural materials; recovering strategic minerals; and the development of biosensors. Some companies are even looking to the 21st century and the realization of biomolecular electronic devices. In the future, there will be significant advances in all areas of industry mentioned resulting in a bioindustry with projected worldwide sales of 100 billion dollars by the turn of the century.

Within the next decade, medicine will be revolutionized by a host of new products and technologies. In addition to immunotoxins, other anticancer drugs and immune system modifiers will be available to treat cancer and other diseases. Products acquired by genetic engineering will be developed for treating cardiovascular disease and will permit physicians to dissolve blood clots, treat high blood pressure better, and reduce the probability of stroke and heart attack in high risk groups.

Certain rare genetic-deficiency diseases will be treatable as well. Frequently such diseases result from the inability of an individual to produce a single enzyme. Bone marrow cells will be removed; the gene coding for the missing enzyme introduced into the cells which, when returned to the patient, will proliferate and produce the lacking enzyme and cure the patient.

Monoclonal antibodies have been used extensively in research and are currently being used in a variety of ways for diagnosing diseases. Others will follow and eventually permit "medicine cabinet" diagnosis of some diseases.

Yet another emerging area for medicine involves the creation of DNA probes through genetic manipulation. Small, unique pieces of DNA from disease-causing microbes are identified, synthesized and labelled either with radioactive compounds or fluorescent dyes. These probes are very specific for a particular microorganism, have the ability to bind with DNA of the microbe, and thereby detect very quickly and accurately small numbers of microorganisms in clinical specimens from patients. This in turn will significantly aid physicians in providing more rapid and better health care.

Human insulin and human growth hormone are already available commercially for treating diabetes and dwarfism, respectively. Both of these

compounds were obtained through genetic engineering. Other therapeutics such as interferon, interleukin, tumor necrosis factor, and tissue plasminogen activator are in various stages of development and clinical testing.

Additionally, any number of new and better vaccines for presently uncontrollable diseases can be expected in the years to come. One of the most promising, which has been developed through genetic engineering, is for malaria which affects hundreds of millions of people worldwide.

Yet another area of concentrated research is the combined use of monoclonal antibodies and anticancer drugs resulting in immunotoxins which hold the promise of treating different types of cancer. In this case, monoclonal antibody produced against cancer antigen on the surface of cancer cells is attached to an anticancer drug. When introduced into a patient, immunotoxins attach only to cancer cells and kill them. Although still in the R&D phase, one such immunotoxin has been created by attaching monoclonal antibodies to ricin, an extremely potent toxin, produced by the castor bean plant. Yet other immunotoxins have been synthesized using standard anticancer drugs and are in clinical testing.

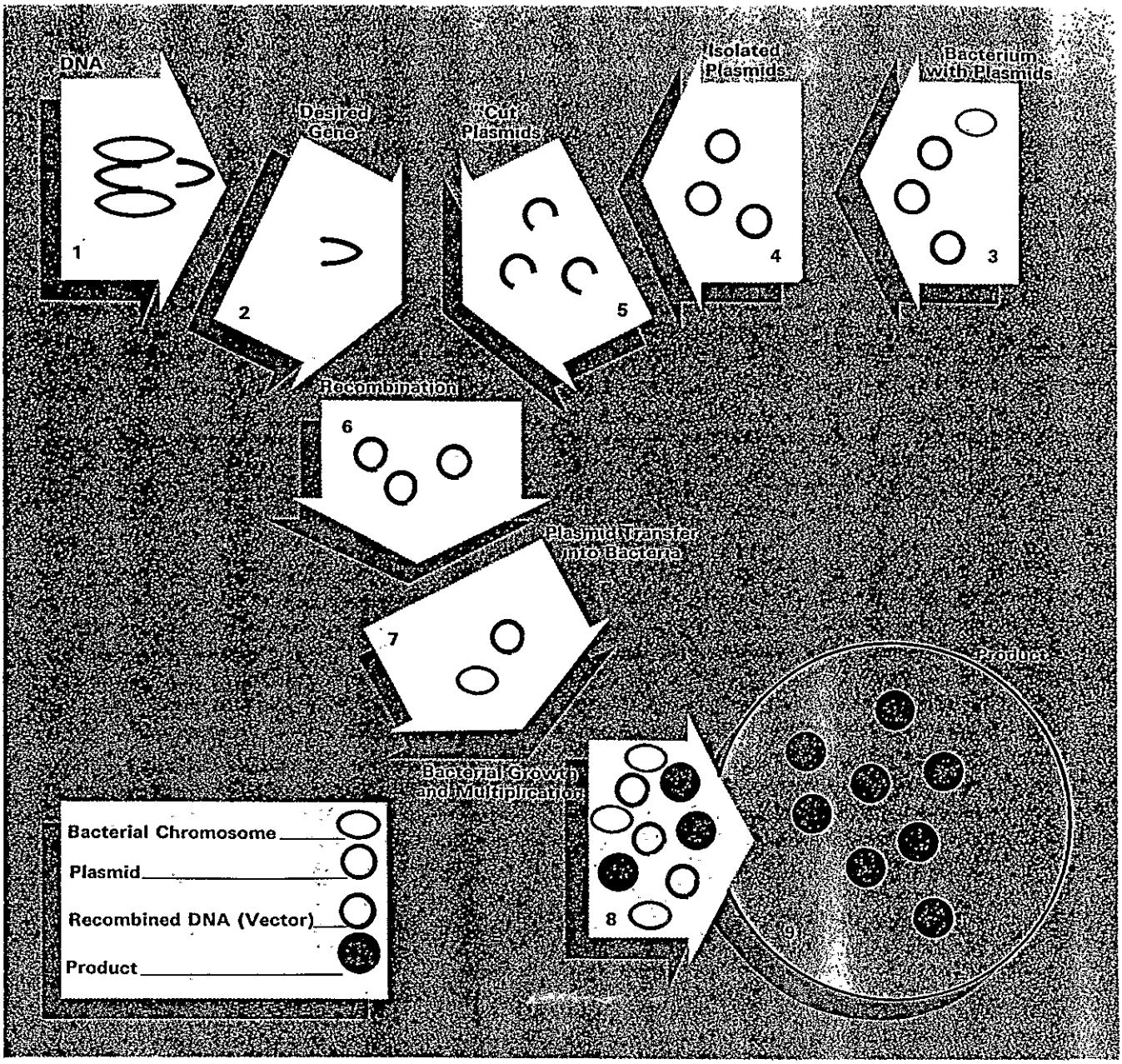
New materials ranging from light weight, superstrong structural products to bioplastics, bioadhesives, and biolubricants will appear on the market. This will enable a variety of industries to improve significantly their current products and expand their product lines.

One area in which biotechnology will have its most profound affect is in agriculture. Plants will be made more tolerant to heat, pollution, arid conditions, and temperature which will permit areas of the world to be cultivated where previously impossible. New fuels will be produced from agricultural biomass which is now considered waste and will help to conserve petroleum resources. The burdensome process of creating hybrid strains of crops will be made faster, more economical and selective. This area will experience some of the most rapid advancement. Some crops have already been genetically engineered to be herbicide-resistant and are being evaluated. This will enable farmers to control weeds more efficiently, thereby making some foods more affordable. Plants will be engineered to grow more quickly for areas with short growing seasons. Tolerance to drought will not only increase the total cultivable land but help insulate farmers from unpredictable and devastating droughts. As a result of these and many more advances, the world's food supply will be cheaper, larger and more consistent. Lesser developed countries, now importers of food, will become self-sufficient. More and improved food supplies, combined with better and more widespread health care, will hopefully in the long-run be stabilizing factors in the world.

Biological Warfare Applications

For military purposes, biotechnology has opened up a large number of possibilities. Normally harmless, non-disease producing microorganisms can be modified to become highly toxic or produce diseases for which an opponent has no known treatment or vaccine. Other disease agents now considered too unstable for storage or warfare applications can be modified using genetic engineering to be effective BW agents.

As advances in biotechnology are made, the potential for applying them to BW increases significantly. The development of agents having optimal weapons potential is facilitated; basic research-to-mass production of agents is accelerated; and distinguishing between peaceful research, development and production and its application for BW purposes becomes more difficult. Finally, we believe smaller nations are going to opt for the BW weapon as they acquire biotechnological capabilities.



Gene Transfer

The Steps Involved in Gene Transfer

Step 1:

Deoxyribonucleic acid (DNA) is extracted from animal, plant or microbial cells. The desired gene is "cut" out of the DNA using a restriction endonuclease enzyme. The gene may code for the production of some human product, such as insulin, if isolated from the DNA of human cells. Likewise genes may be "cut" from the DNA of plant or microbial cells.

Step 2:

The desired animal, plant or microbial gene is isolated.

Step 3:

Some bacteria contain small, circularly arranged pieces of DNA, called plasmids. These plasmids are in addition to the one large, circular chromosome (genome) which codes for what the bacterium looks like and how it functions. Plasmid-containing bacteria are naturally occurring. The plasmids are frequently associated with conferring antibiotic resistance to bacteria and/or the ability to produce toxins. Some plasmids can be used as a means of transferring genes from animals, plants or microbes into bacteria and, as such, are termed vectors.

Step 4:

Plasmids are released from bacteria and purified.

Step 5:

The plasmids are "cut" with the same type of restriction endonuclease enzyme used to excise the desired gene from the animal, plant or microbial cells. This step prepares the plasmid for gene insertion.

Step 6:

The plasmids are mixed with the gene in the presence of yet another enzyme, called ligase, which unites the plasmid and gene. At this point, a piece of recombinant DNA exists and will serve as the vector for the gene.

Step 7:

The recombined plasmids are exposed to bacteria. Once the plasmids get inside the bacterial cells, the cells begin synthesizing the substance coded by the gene.

Step 8:

Bacteria containing the recombinant plasmids are grown under conditions which permit their rapid growth and multiplication. Each time bacteria divide, the plasmid is replicated so that all the bacteria contain the plasmid. The common intestinal bacterium, *Escherichia coli,* is frequently used for the production of recombinant DNA products and in effect makes the cells biological factories which synthesize the product coded by the gene. Under ideal conditions, *E. coli* cells can divide once every 20 minutes. As a result, one cell can multiply to over a billion cells in about 10 hours. During growth and multiplication, the gene product is produced. The product is either released by the bacteria into the surrounding medium, or retained inside the cells. In the latter case, the bacteria must be broken open to release the product.

Step 9:

In the final step, the product is recovered and purified. A recombinant DNA product such as insulin must be highly purified since it will be used in humans.

APPENDIX B

GENEVA PROTOCOL OF 1925

Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare

Signed at Geneva June 17, 1925
Entered into force February 8, 1928
Ratification advised by the U.S. Senate December 16, 1974
Ratified by U.S. President January 22, 1975
U.S. ratification deposited with the Government of France April 10, 1975
Proclaimed by U.S. President April 29, 1975

The Undersigned Plenipotentiaries, in the name of their respective Governments:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilized world; and

Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the World are Parties; and

To the end that this prohibition shall be universally accepted as part of International Law, binding alike the conscience and the practice of nations;

Declare:

That the High Contracting Parties, so far as they are not already Parties to Treaties prohibiting such use, accept this prohibition, agree to extend this prohibition to the use of bacteriological methods of warfare and agree to be bound as between themselves according to the terms of this declaration.

The High Contracting Parties will exert every effort to induce other States to accede to the present Protocol. Such accession will be notified to the Government of the French Republic, and by the latter to all signatory and acceding Powers, and will take effect on the date of the notification by the Government of the French Republic.

The ratifications of the present Protocol shall be addressed to the Government of the French Republic, which will at once notify the deposit of such ratification to each of the signatory and acceding Powers.

The instruments of ratification of and accession to the present Protocol will remain deposited in the archives of the Government of the French Republic.

The present Protocol will come into force for each signatory Power as from the date of deposit of its ratification, and, from that moment, each Power will be bound as regards other powers which have already deposited their ratifications.

IN WITNESS WHEREOF the Plenipotentiaries have signed the present Protocol.

DONE at Geneva in a single copy, this seventeenth day of June, One Thousand Nine Hundred and Twenty-Five.

States Parties to the Protocol for the Prohibition of the use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, Done at Geneva June 17, 1925

States which have deposited instruments of ratification or accession, or continue to be bound as the result of succession agreements concluded by them or by reason of notification given by them to the Secretary-General of the United Nations:

Argentina–May 12, 1969
1 a b Australia–Jan. 22, 1930
Austria–May 9, 1928

1 a b 2 Bahamas, The
2 Barbados–June 22, 1976
1 a b Belgium–Dec. 4, 1928
6 Bhutan–June 12, 1978[6]
1 a b 2 Botswana
Brazil–Aug. 28, 1970
1 a b Bulgaria–Mar. 7, 1934
1 a b 2 Burma

1 a b Canada–May 6, 1930
Central African Republic–July 31, 1970
1 a b Chile–July 2, 1935
1 a b China, People's Republic of–Aug. 9, 1952
China (Taiwan)–Aug. 7, 1929
7 Comoros
Cuba–June 24, 1966
Cyprus–Dec. 12, 1966
1 b Czechoslovakia–Aug. 16, 1938

Denmark–May 5, 1930
7 Djibouti
Dominican Republic–Dec. 8, 1970

Ecuador–Sept. 16, 1970
Egypt–Dec. 6, 1928
1 a b Estonia–Aug. 28, 1931
Ethiopia–Sept. 18, 1935

1 a b Fiji–Mar. 21, 1973
Finland–June 26, 1929
1 a b 3 France–May 9, 1926

Gambia, The–Nov. 16, 1966
German Democratic Republic
Germany, Federal Republic of–
Apr. 25, 1929
Ghana–May 3, 1967

Greece–May 30, 1931
1 a b Grenada
1 a b 2 Guyana

Holy See–Oct. 18, 1966
Hungary–Oct. 11, 1952

Iceland–Nov. 2, 1967
1 a b India–Apr. 9, 1930
Indonesia–Jan. 26, 1971
Iran–July 4, 1929
1 a b Iraq–Sept. 8, 1931
Ireland–Aug. 18, 1930
1 a b Israel–Feb. 20, 1969
Italy–Apr. 3, 1928
Ivory Coast–July 27, 1970

Jamaica–July 31, 1970
Japan–May 21, 1970
1 a b d Jordan–Jan. 20, 1977

Kenya–July 6, 1970
1 a b d Kuwait–Dec. 15, 1971

Latvia–June 3, 1931
Lebanon–Apr. 17, 1969
Lesotho–Mar. 15, 1972
Liberia–Apr. 2, 1927
1 b d Libya–Dec. 29, 1971
Lithuania–June 15, 1933
Luxembourg–Sept. 1, 1936

Madagascar–Aug. 12, 1967
Malawi–Sept. 14, 1970
Malaysia–Dec. 10, 1970
Maldive Islands–Jan. 16, 1967
Mali–Nov. 19, 1966
Malta–Oct. 15, 1970
Mauritius–Jan. 8, 1971
Mexico–Mar. 15, 1932
Monaco–Jan. 6, 1967

1 b	Mongolia–Dec. 6, 1968
	Morocco–Oct. 13, 1970
	Nepal–May 9, 1969
1 c 4	Netherlands–Oct. 31, 1930
1 a b	New Zealand–Jan. 22, 1930
	Niger–Apr. 19, 1967
1 a b	Nigeria–Oct. 15, 1968
	Norway–July 27, 1932
	Pakistan–June 9, 1960
	Panama–Dec. 4, 1970
1 a b	Papua New Guinea–Sept. 16, 1975
	Paraguay–Jan. 14, 1969
	Philippines–May 29, 1973
	Poland–Feb. 4, 1929
1 a b	Portugal–July 1, 1930
	Qatar–Sept. 16, 1976
1 a b	Romania–Aug. 23, 1929
	Rwanda–June 25, 1964
	Saudi Arabia–Jan. 27, 1971
1 a b 2	Seychelles
	Sierra Leone–Mar. 20, 1967
1 a b 2	Singapore
1 a b	South Africa–Jan. 22, 1930
1 a b	Spain–Aug. 22, 1929
	Sri Lanka–Jan. 20, 1954
	Sudan–Dec. 17, 1980
1 c 4	Suriname
1 a b 2	Swaziland
	Sweden–Apr. 25, 1930
	Switzerland–July 12, 1932
1 d	Syrian Arab Republic–Dec. 17, 1968
	Tanzania–Apr. 22, 1963
	Thailand–June 6, 1931
	Togo–Apr. 5, 1971
	Tonga–July 28, 1971
	Trinidad and Tobago–Nov. 30, 1970
	Tunisia–July 12, 1967
	Turkey–Oct. 5 1929
	Uganda–May 24, 1965
1 a b	Union of Soviet Socialist Republics–Apr. 5, 1928
1 a b 5	United Kingdom–Apr. 9, 1930
1 c	United States–Apr. 10, 1975
	Upper Volta–Apr. 12, 1977
	Uruguay–Apr. 12, 1977
	Venezuela–Feb. 8, 1928
1 a b	Vietnam–Sept. 23. 1980
1 b	Yemen Arab Republic (Sana)–Mar. 17, 1971
	Yugoslavia–Apr. 12, 1929
1 a b 2	Zambia

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1 a, b, c, d With reservations to Protocol as follows:

a—binding only as regards relations with other parties.

b—to cease to be binding in regard to any enemy States whose armed forces or allies do not observe provisions.

c—to cease to be binding as regards use of chemical agents with respect to any enemy State whose armed forces or allies do not observe provisions.

d—does not constitute recognition of or involve treaty relations with Israel.

2 By virtue of agreement with former parent State or notification to the Secretary General of the United Nations of succession to treaty rights and obligations upon independence.

3 Applicable to all French territories.

4 Applicable to Suriname and Curacao.

5 It does not bind India or any British Dominion which is a separate member of the League of Nations and does not separately sign or adhere to the Protocol. It is applicable to all colonies.

6 Deposited accession on June 12, 1978, but the French Government asked that accession take effect on date of notification by them—Feb. 19, 1979.

7 Included in declaration by France. Continued application has apparently not been determined.

APPENDIX C

THE BIOLOGICAL AND TOXIN WEAPONS CONVENTION OF 1972

Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction

Signed at Washington, London, and Moscow April 10, 1972
Ratification advised by U.S. Senate December 16, 1974
Ratified by U.S. President January 22, 1975
U.S. ratification deposited at Washington, London, and Moscow March 26, 1975
Proclaimed by U.S. President March 26, 1975 Entered into force March 26, 1975

The States Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction, and convinced that the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and their elimination, through effective measures, will facilitate the achievement of general and complete disarmament under strict and effective international control,

Recognizing the important significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925, and conscious also of the contribution which the said Protocol has already made, and continues to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply strictly with them,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Geneva Protocol of June 17, 1925,

Desiring to contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere,

Desiring also to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Convinced of the importance and urgency of eliminating from the arsenals of States, through effective measures, such dangerous weapons of mass destruction as those using chemical or bacteriological (biological) agents,

Recognizing that an agreement on the prohibition of bacteriological (biological) and toxin weapons represents a first possible step towards the achievement of agreement on effective measures also for the prohibition of the development, production and stockpiling of chemical weapons, and determined to continue negotiations to that end,

Determined, for the sake of all mankind, to exclude completely the possibility of bacteriological (biological) agents and toxins being used as weapons, Convinced that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimize this risk,

Have agreed as follows:

Article I

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, protective 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.

Article II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than nine months after the entry into force of the Convention, all agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, which are in its possession or under its jurisdiction or control. In implementing the provisions of this article all necessary safety precautions shall be observed to protect populations and the environment.

Article III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in article I of the Convention.

Article IV

Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

Article V

The States to this Convention undertake to consult one another and to cooperate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, the Convention. Consultation and cooperation pursuant to this article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

Article VI

(1) Any State Party to this Convention which finds that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council.

(2) Each State Party to this Convention undertakes to cooperate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties to the Convention of the results of the investigation.

Article VII

Each State Party to this Convention undertakes to provide or support assistance, in accordance with the United Nations Charter, to any Party to the Convention which so requests, if the Security Council decides that such Party has been exposed to danger as a result of violation of the Convention.

Article VIII

Nothing in this Convention shall be interpreted as in any way lisiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on June 17, 1925.

Article IX

Each State Party to this Convention affirms the recognized objective of effective prohibition of chemical weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.

Article X

(1) The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of bacteriological (biological) agents and toxins for peaceful purposes. Parties to the Convention in a position to do so shall also cooperate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of bacteriology (biology) for prevention of disease, or for other peaceful purposes.

(2) This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international cooperation in the field of peaceful bacteriological (biological) activities, including the international exchange of bacteriological (biological) agents and toxins and equipment for the processing, use or production of bacteriological (biological) agents and toxins for peaceful purposes in accordance with the provisions of the Convention.

Article XI

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party on the date of acceptance by it.

Article XII

Five years after the entry into force of this Convention, or earlier if it is requested by a majority of Parties to the Convention by submitting a proposal to this effect to the Depositary Governments, a conference of States Parties to the Convention 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, including the provisions concerning negotiations on chemical weapons, are being realized. Such review shall take into account any new scientific and technological developments relevant to the Convention.

Article XIII

(1) This Convention shall be of unlimited duration.

(2) Each State Party to this Convention shall in exercising its national sovereignty have the right to withdraw from the Convention if it decides that extraordinary events, related to the subject matter of the Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to the Convention and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

Article XIV

(1) This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph (3) of this Article may accede to it at any time.

(2) This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland and the Union of Soviet Socialist Republics, which are hereby designated the Depositary Governments.

(3) This Convention shall enter into force after the deposit of instruments of ratification by twenty-two Governments, including the Governments designated as Depositaries of the Convention.

(4) For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

(5) The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession and the date of the entry into force of this Convention, and of the receipt of other notices.

(6) This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article XV

This Convention, the English, Russian, French, Spanish and Chinese texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of the Convention shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding states.

IN WITNESS WHEREOF the undersigned, duly authorized, have signed this Convention.

DONE in triplicate, at the cities of Washington, London and Moscow, this tenth day of April, one thousand nine hundred and seventy-two.

Country	Date of[1] Signature	Date of Deposit[1] of Ratification	Date of Deposit[1] of Accession
Afghanistan	4/10/72	3/26/75	
Argentina	8/01/72	11/27/79	
Australia	4/10/72	10/05/77	
Austria	4/10/72	8/10/73	
Barbados	2/16/73	2/16/73	
Belgium	4/10/72	3/15/79	
Benin	4/10/72	4/25/75	
Bhutan		6/08/78	
Bolivia	4/10/72	10/30/75	
Botswana	4/10/72		
Brazil	4/10/72	2/27/73	
Bulgaria	4/10/72	8/02/72	
Burma	4/10/72		
Burundi	4/10/72		
Byelorussian S.S.R.[2]	4/10/72	3/26/75	

Country	Date of[1] Signature	Date of Deposit[1] of Ratification	Date of Deposit[1] of Accession
Cambodia (Kampuchea)	4/10/72	3/09/83	
Canada	4/10/72	9/18/72	
Cape Verde			10/20/77
Central African Republic	4/10/72		
Chile	4/10/72		
China, Peoples Republic of			10/15/84
China (Taiwan)	4/10/72	2/9/73	
Colombia	4/10/72	12/19/83	
Congo, People's Republic of (Brazzaville)			10/23/78
Costa Rica	4/10/72	12/17/73	
Cuba	4/12/72	4/21/76	
Cyprus	4/10/72	11/06/73	
Czechoslovakia	4/10/72	4/30/73	
Denmark	4/10/72	3/01/73	
Dominican Republic	4/10/72	2/23/73	
Ecuador	6/14/72	3/12/75	
Egypt	4/10/72		
El Salvador	4/10/72		
Ethiopia	4/10/72	6/26/75	
France	10/15/84	10/15/84	
Fiji	2/22/73	9/04/73	
Finland	4/10/72	2/04/74	
Gabon	4/10/72		
Gambia, The	6/02/72		
German Democratic Republic	4/10/72	11/28/72	
Germany, Federal Republic	4/10/72	4/07/83	
Ghana	4/10/72	6/06/75	
Greece	4/10/72	12/10/75	
Guatemala	5/09/72	9/19/73	
Guinea-Bissau			8/20/76
Guyana	1/03/73		
Haiti	4/10/72		
Honduras	4/10/72	3/14/79	
Hungary	4/10/72	12/27/72	
Iceland	4/10/72	2/15/73	
India	1/15/73	7/15/74	
Indonesia	6/20/72		
Iran	4/10/72	8/22/73	
Iraq	5/11/72		
Ireland	4/10/72	10/27/72	
Italy	4/10/72	5/30/75	
Ivory Coast	5/23/72		

Country	Date of[1] Signature	Date of Deposit[1] of Ratification	Date of Deposit[1] of Accession
Jamaica			8/13/75
Japan	4/10/72	6/04/82	6/18/82
Jordan	4/10/72	6/02/75	
Kenya			9/30/81
Korea, Republic of	4/10/72		
Kuwait	4/14/72	7/18/72	
Laos	4/10/72	3/20/73	
Lebanon	4/10/72	6/13/75	
Lesotho	4/10/72		
Liberia	4/10/72		
Libya			1/19/82
Luxembourg	4/10/72	3/23/76	
Madagascar	10/13/72		
Malawi	4/10/72		
Malaysia	4/10/72		
Mali	4/10/72		
Malta	9/11/72	4/07/75	
Mauritius	4/10/72	8/07/72	
Mexico	4/10/72	4/08/74	
Mongolia	4/10/72	9/05/72	
Morocco	5/02/72		
Nepal	4/10/72		
Netherlands	4/10/72	6/22/81	
New Zealand	4/10/72	12/13/72	
Nicaragua	4/10/72	8/07/75	
Niger	4/21/72	6/23/72	
Nigeria	7/03/72	7/03/73	
Norway	4/10/72	8/01/73	
Pakistan	4/10/72	9/25/74	
Panama	5/02/72	3/20/74	
Papua New Guinea			10/27/80
Paraguay			6/09/76
Peru	4/10/72	6/05/85	
Philippines	4/10/72	5/21/73	
Poland	4/10/72	1/25/73	
Portugal	6/29/72	5/15/75	
Qatar	11/14/72	4/17/75	
Romania	4/10/72	7/25/79	
Rwanda	4/10/72	5/20/75	
San Marino1p	9/12/72	3/11/75	
Sao Tome and Principe			8/24/79
Saudi Arabia	4/12/72	5/24/72	

Country	Date of[1] Signature	Date of Deposit[1] of Ratification	Date of Deposit[1] of Accession
Senegal	4/10/72	3/26/75	
Sierra Leone	11/07/72	6/29/76	
Seychelles			10/24/79
Singapore	6/19/72	12/02/75	
Somalia	7/03/72		
South Africa	4/10/72	11/03/75	
Spain	4/10/72	6/20/79	
Sri Lanka	4/10/72		
Sweden	2/27/75	2/05/76	
Switzerland	4/10/72	5/04/76	
Syrian Arab Republic	4/14/72		
Tanzania	8/16/72		
Thailand	1/17/73	5/28/75	
Togo	4/10/72	11/10/76	
Tonga			9/30/81
Tunisia	4/10/72	5/18/73	
Turkey	4/10/72	11/5/74	
Ukrainian S.S.R.[2]	4/10/72	3/26/75	
Union of Soviet Socialist Republics	4/10/72	3/26/75	
United Arab Emirates	9/28/72		
United Kingdom	4/10/72	3/26/75	
United States	4/10/72	3/26/75	
Uruguay			4/16/81
Venezuela	4/10/72	10/18/78	6/20/80
Yemen Arab Republic (Sana)	4/10/72		
Yemen, People's Democratic Republic of (Aden)	4/26/72	6/01/79	
Yugoslavia	4/10/72	10/25/73	
Zaire	4/10/72	9/16/75	
Total[3]	**113**	**84**	**16**

[1] Dates given are the earliest dates on which countries signed the agreements or deposited their ratifications or accessions-whether in Washington, London, Moscow, or New York. In the Case of a country that was a dependent territory which became a party through succession, the date given is the date on which the country gave notice that it would continue to be bound by the terms of the agreement.

[2] The United States regards the signature and ratification by the Byelorussian S.S.R. and the Ukrainian S.S.R. as already included under the signature and ratification of the Union of Soviet Socialist Republics.

[3] This total does not include actions by the Byelorussian S.S.R. and the Ukrainian S.S.R. (See footnote 2.)

APPENDIX D

BIOLOGICAL WARFARE AGENT DESTRUCTION: HOW WOULD THE SOVIETS DO IT?

BIOLOGICAL WARFARE AGENT DESTRUCTION

When, and if, Soviet BW agents are destroyed, universally applicable microbiological principles and methods would have to be followed to ensure safe handling and neutralization of the infectious agents. Physical (heat) and chemical (liquid and gas disinfectants) methods are available for killing microorganisms. Not all, however, are useful for large-scale operations involving human pathogens.

The method(s) of choice would be determined by the: (1) type of agent (such as bacterial or viral), (2) amount of agent, (3) type of packaging (munition/non-munition or bulk/small lot), (4) form of agent (dried or liquid), and (5) whether the agent is a human or non-human pathogen. The causative agent of anthrax, *Bacillus anthracis,* when dried and in spore-form, is one of the most difficult organisms to handle safely and destroy.

General guidelines indicating a possible Soviet mode(s) of destruction can be drawn from the U.S. program which resulted in the complete and safe disposal of our BW inventory in the early 1970's. Destruction of agents occurred on-site at four production/storage facilities by multi-step processes. The decontamination process began with transport of agent from on-site storage facilities to decontamination buildings, and ended with incorporation of sterilized agent into surface soil, burial at the disposal sites, or biodegradation in sewage treatment plants. Intervening steps relied primarily on sterilization by heat but included chemical disinfection and/or incineration depending on whether the agent was in liquid or dried powder form.

Prior to, during and after the sterilization process, agent viability was monitored to ensure complete killing. Regardless of the type of agents and their location of storage and destruction, all plans were designed to ensure: (1) absolute safety of operating personnel and maximal protection of the environment, (2) strict accountability of all the agents, (3) acquisition of incontrovertible evidence for complete destruction and disposal of stocks, and (4) provision for independent observers to witness destruction.

Materials destroyed included:

- Liquid agents stored as frozen pellets
- Bulk dry materials
- Bulk stocks of toxins
- Biological munitions (filled and unfilled)

Destruction of agents took approximately twelve months. The presence of dried, bulk-stored spores in the U.S. inventory represented one of the most difficult of all bacteriological agents to destroy due to their innate resistance to heat and chemical disinfection. Nonetheless, the U.S. effort was successful.

The destruction process for both dry and liquid agents began by transportation in containment vehicles to decontamination buildings maintained under negative pressure and with absolute air filtration systems. Initially, the liquid and dry agents were handled differently since dry agents first had to be suspended in a liquid chemical disinfectant to minimize aerosolization and to enable contained pumping, as a slurry, to holding/sterilization tanks. Thereafter, all the agents were neutralized by three cycles of heating at 160°F for one hour, 280°F for three hours and 300°F for ten minutes.

Heating was the primary method of sterilization and had the advantages of being:

- Applicable to large scale operations
- Universally effective against all types of microorganisms
- Easily controllable
- Reasonably fast
- Available at production facilities

Although the U.S. tested other methods such as chemical digestion or burning the materials in their storage containers, neither was satisfactory. No practical alternatives to prolonged, cyclical heating were found to provide the exceptionally high degree of safety required and the ability to insure total destruction of the viable materials. Heating, therefore, could be found by the Soviets to be the best method for destroying their BW inventory. Such a method, which is capable of neutralizing anthrax spores, in all likelihood would be suitable for any other agents the Soviets have in their inventory with the exception of mycotoxins which would require more intense and prolonged neutralization.

An explosives deactivation furnace and smelter had to be installed in the munitions filling and assembly building. The munitions' charges and components were incinerated in the furnace, whereas non-combustible components were smelted. Biological agents in the munitions were first removed and neutralized.

The BW agent containers were composed of both combustible and non-combustible materials. Plastic carboys and bags were either filled or covered with disinfectant, sterilized for three hours at 250°F and incinerated. Glass and metal containers were sterilized by two cycles of heating at 250°F for three hours.

All personnel involved in the decontamination process were highly trained and experienced in handling pathogenic microorganisms. The individuals were all protected by immunization and appropriate protective clothing. Disposal operations of agents used the same, or stricter controls, than were used during manufacture.

As previously noted we are confident that the Soviets would abide by basic antiseptic and disinfection principles applicable to all human, animal and plant pathogens. There is no question that they understand these principles based on their long history of combating infectious diseases, identifying foci of infection, and treating and controlling their spread. Any differences with U.S. methods would probably be in style and not substance.