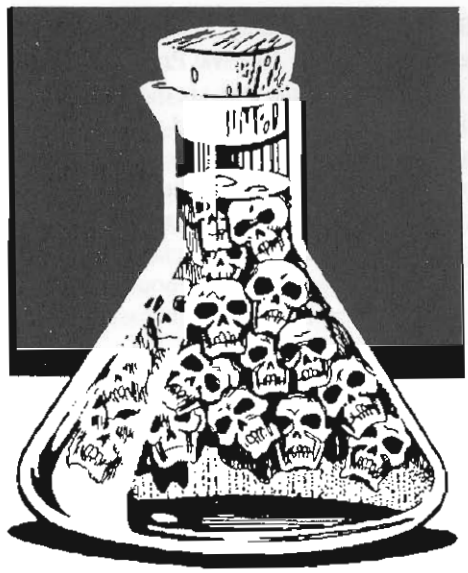
Biological Warfare

—its technical aspects



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with
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In the January 1996 issue of CML, we presented the first part of Colonel Larsen's article. In this article we explore the technical aspects of biological warfare. In our next issue, we'll feature Part 3 of his article, The BW Threat to Strategic Mobility Forces.

—Editor

The 1992 NATO Handbook defines a biological warfare (BW) agent as "a microorganism (or a toxin derived from it) which causes disease in man, animals, or plants, or which causes the deterioration of material." This article, however, will focus exclusively on those agents which affect humans.

A biological warfare program consists of five elements: agents, production capability, weaponization, delivery systems, and detection/defensive measures. To fully appreciate the threat of biological warfare and the difficulties associated with nonproliferation efforts, a basic understanding of these five elements is required.

Agents

There are approximately 160 known disease-causing species that affect humans. Of these, more than 60 are discussed in open literature as potential BW agents. Suitability for use as a BW agent is determined by four characteristics.

Infectivity/virulence. A small dose should produce a predictable response such as death or incapacitation. (Virtually 100 percent of those exposed to the Ebola Zaire virus will contact the disease [infectivity] and 90 percent will die even with intensive medical care [virulence]). The term infectious should not be confused with contagious. Individuals infected with Q Fever, pulmonary anthrax, typhoid, or toxins cannot transmit these diseases to other people. On the other hand, individuals infected with contagious diseases, such as smallpox, influenza, and some other types of viruses, can transmit these diseases to those around them.

Producibility. Most production problems were solved in the 1960s. Large quantities of BW agents can be rapidly produced in fermentors used by pharmaceutical companies and breweries. For some agents, such as anthrax, a room the size of an average two-car garage could house a production plant capable of growing sufficient quantities to devastate the population of a dozen major cities. This production facility could be built from scratch, produce this quantity of agent, and be dismantled all in less than one month. This fact alone makes treaty verification a virtual impossibility.

Stability. Stability refers to the resistance an agent has to the effects of ultraviolet light, heat, cold, and other environmental factors. In their natural state, biological agents decay rapidly when exposed to these environmental factors. However, chemicals developed by the United States BW program in the 1960s greatly minimize these effects. Many suspect the Soviets made even more sophisticated improvements in heartiness through the use of bio-engineering and micro-encapsulation during their research, development, and production programs that continued long after the United States unilaterally terminated its offensive BW program in 1969.

Ability to disseminate. While dissemination of BW agents is possible through water/food and vectors (such as ticks), the primary threat is through inhalation of aerosolized particles.

BW agents can be divided into four categories. (See table below.)

Bacteria	Rickettsia	Viruses	Toxins
Anthrax	Q Fever	Small Pox	Botulinum
Plague	Typhus	Ebola Zaire	Ricin

Bacteria are the only agents outlawed by the 1925 Geneva Protocol, and in layman's terms, they are the only "living" agents. Rickettsia and viruses are strands of DNA that are only "alive" (capable of reproduction) when they have invaded a living cell. Toxins are chemicals produced by biological organisms, such as snake venom or ricin—a chemical extracted from castor beans.

The lethality of these agents is extraordinary, even when compared to the most potent chemical warfare agents. For instance, 10 grams of anthrax spores could kill as many people as a ton of the nerve agent, Sarin. With ideal conditions (a clear, calm night), a single aircraft using an efficient aerosol generator to dispense 100 kg of anthrax spores, could adequately cover a 300 km^2 area (approximately the size of Washington, DC), and inflict between 1,000,000 and 3,000,000 deaths (assuming 3,000–10,000 people/km^2).

According to a 1970 World Health Organization Report:

Inhalation of one microscopic (anthrax) spore will result in death within 48 hours. The mean lethal inhalatory dosage is 10^{-8} grams or, in principle, were the spores distributed appropriately, one gram would be enough to kill more than one-third of the population of the United States.

When the US unilaterally withdrew from research and development of offensive biological weapons in 1969, 20 of 31 agents considered to be potential BW agents were either bacteria or fungi. However, by the early 1980s, viruses were considered to be the BW agent of choice, and there was great concern the Soviets were engaged in research and development of virus-based weapons. A 1983 report from US Army Health Services Command stated that 19 of 22 BW agents that US forces might likely encounter were viruses, including Ebola Zaire.

Several nations were known to have obtained samples of the Ebola Zaire virus during "burns" through African villages. Ebola Zaire is the deadliest virus known and extremely contagious—thus the term "burn" is used to describe the path is can take through a village or urban area. In 1976, it burned through 55 villages, killing nine out of ten people infected. There is neither vaccine nor cure for this virus.

The United States Army Medical Research Institute of Infectious Diseases (USAMRIID) and the Centers for Disease Control (CDC) classifies Ebola Zaire as a Biosafety Level 4 substance. The AIDS virus is classified as Biosafety Level 2. USAMRIID personnel, like health care workers, routinely handle samples of blood containing the AIDS virus with no protection other than surgical gloves (normally two layers). When USAMRIID personnel handle blood or tissue samples containing Ebola Zaire, they wear spacesuit-like protection.

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One aspect of biological warfare often overlooked is that not all agents are lethal. A nonlethal agent, such as influenza, is highly infectious (the vast majority of unprotected individuals in the target area will contact the disease), highly contagious (individuals infected by aerosol weapons will transmit the disease to others who were not infected during the BW attack), and will incapacitate infected individuals for several days, but in most cases, will not cause fatalities.

According to the US Army, the only good news about biological warfare is that most BW agents are not generally considered persistent. The words "most" and "generally" are, in the author's opinion, major caveats. This is not, however, a criticism of the Army's findings. The Army's mission is to seize and hold ground using well-trained, well-equipped soldiers. From the Army's perspective, biological agents are not highly useful for terrain denial. A much better weapon of choice for terrain denial would be a chemical agent, such as dusty mustard. An enemy force could lay dusty mustard in a mountain pass to prevent a surprise attack by US forces on its flank or to seriously impede attacking forces during a retreat. For several reasons, including persistence and length of time required to produce incapacity or death, BW agents would not be a suitable terrain denial weapon for use against well-equipped, well-trained forces.

On the other hand, biological agents could serve as a superb terrain denial weapon against soft targets, such as sea and airports that are primarily operated by civilians. This issue will be discussed in detail later.

Production Capability

Accessibility to small quantities of BW agents has never been a problem. Anthrax spores exist wherever there are large populations of sheep. Ricin can be extracted from castor beans by any competent high school biology student. Botulinum Type A, the most lethal toxin known, can be produced from bacterial strains that are readily isolated in nature.

Other agents, particularly some toxins, are widely used in medical research on neuromuscular diseases. Virtually any agent can be legally acquired from organizations such as the American Type Culture Collection (ATCC) in Rockville, Maryland. ATCC is a legitimate corporation that serves the worldwide medical research community. The Stockholm International Peace Research Institute (SIPRI) notes that ATCC installed an 800 number to improve customer service. One of its customers, however, was the Iraqi government, which purchased anthrax and four other agents used in their biological weapons program.

Prior to the 1940s, moving from "laboratory quantities" to "weapons quantities" was a difficult process that required a significant capital and technological commitment. This is no longer true. During World War II and the two decades that followed, significant technological advances were made that allowed rapid, large-scale production of biological agents. Today, all necessary supplies and equipment for the large-scale production of BW agents can be acquired commercially. Any country that possesses even the most primitive pharmaceutical or biomedical laboratory has the scientific and technical know-how and the infrastructure required to mass produce biological agents. Commercial fermentors, ranging in size from 10,000 to 1 million liters, are in use throughout the pharmaceutical, agricultural, and brewing industries.

Biological warfare agents can be produced in either liquid or dry powdered form. Liquid agents are the cheapest and safest to produce, but require special handling during transport and storage to minimize biological decay (excluding toxins). Dried powder agents offer increased stability and improved dissemination efficiency, particularly with off-the-shelf technology, but do create safety hazards during production.

Weaponization

The limited success of the Japanese BW program in World War II was the result of their primitive (natural) dissemination methods—vectors and contaminated food/water. Laboratory and some limited field testing were done on aerosol delivery by the Japanese; however, the environmental effects of bomblet explosions proved to be a highly ineffective method of dissemination.

Following World War II, during the "golden age of biological warfare" (1959–1969), the problems with aerosol delivery were solved by the US, UK, and the Soviets. This breakthrough in weaponization, along with major improvements in production techniques, changed the nature of biological warfare from a terror weapon to a true weapon of mass destruction. According to the US Congress, Office of Technology Assessment, 100 kg of anthrax spores delivered by an efficient aerosol generator on a large urban target would be between two times and six times as lethal as a one megaton thermo-nuclear bomb. (A one megaton hydrogen bomb is 50 times more powerful than the atom bomb that was dropped on Hiroshima.)

Aerosol delivery is the most effective method of dissemination and the only one that will be addressed in this article. To achieve greatest effectiveness, agents must be delivered as a small aerosol particle (1–5 microns in

diameter) to ensure the particles will reach the alveoli in the lungs. Early BW munitions (exploding bomblets) were generally less than 1 percent effective in achieving this aerosolized particle size; however, modern technology has increased this effectiveness. Today, dissemination efficiency rates of 40–60 percent are attainable with off-the-shelf technology. Obviously, higher efficiency rates, perhaps better than 90 percent, are attainable and likely developed by the Soviet/Russian programs.

Effective biological weapons range from 1,000-pound gravity bombs (not explosive devices, but gravity bombs with parachutes and aerosol generators) to backpack spray rigs similar to those carried by commercial exterminators. This wide range of aerosol devices can be transported on an equally wide range of delivery vehicles.

Delivery Systems

Modern BW delivery systems include ballistic and cruise missiles; aircraft carrying either gravity bombs or attached spray units, similar to a crop duster; artillery and mortar shells; surface vehicles including boats, cars, and trucks; and man-portable systems. The most effective type of delivery system depends on the target. Line-source releases (cruise missiles, aircraft-mounted spray units, and surface vehicles) generally provide greater area coverage while point source releases (artillery and mortar shells, man-portable spray units) generally provide higher saturation of a finite area.

A recently completed study on the 1979 Sverdlovsk incident by US and Russian scientists, led by Dr. Matthew Meselson, a Harvard molecular biologist, demonstrates the capability of point source releases. A very small amount of aerosolized anthrax spores, "less than one gram, perhaps as few as a few milligrams," was accidentally released from a Soviet biological warfare facility. At least 96 people were infected and 66 subsequently died, perhaps more. A northwest wind created a narrow plume approximately 50 km long. The majority of humans infected either lived or worked within 4 km of the release point on the morning of 2 April 1979; however, sheep and cows were infected more than 50 km downwind from the release point. Luckily for the local residents, the BW production facility was located on the southern edge of Sverdlovsk (now called Yekaterinburg), and the wind was from the northwest. Had there been a gentle southerly wind that morning, the casualty figures would have been substantially higher.

A line-source release, however, is an even more effective method for area coverage. A single airplane or cruise missile, spraying 50 kg of anthrax (50,000 times more than released at Sverdlovsk) along a 5 km line, would inflict gross casualties over a 40 km^2 area. A small boat or pickup truck can

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also provide a superb delivery system for BW agents. There was great concern during the Gulf War that Iraqi forces could release BW agents from a small boat cruising a few kilometers off the Saudi Arabian coastline. The effects on air bases (such as Dhahran) and sea ports (such as Ad Damman) would have been devastating to the US and coalition's mobility efforts.

One of the best delivery systems is a cruise missile, a system that until recently was considered very high tech and could only be developed by the most advanced nations. In reality, most parts of a cruise missile are no more high-tech than a small airplane. The guidance system, however, used to rely on a combination of the most leading edge navigation technology—terrain matching radar and inertial guidance systems. Unfortunately, the Global Positioning System (GPS) now provides adequate navigation and guidance to virtually anyone who wants it. GPS receivers, capable of providing accurate guidance within several dozen meters, are available through commercial distributors for under $200. This system does not provide the accuracy required for precision munitions, as were used in the Gulf War to attack hardened facilities, but it is more than sufficient to guide cruise missiles armed with biological agents. (To successfully attack hardened facilities, precision guided munitions require accuracy measured in inches. A GPS-guided cruise missile's accuracy would place it several dozen meters either side of its planned flight path. Actually, a miss of 3 to 4 or even as much as 10 kilometers on an airfield or sea port—assuming it was on the upwind side—would still provide a highly successful attack.)

Ballistic missiles, cruise missiles, and airplanes can be detected by radar and to varying degrees, intercepted by air and ground defensive systems. Other delivery systems, however, are not as easy to detect. Small, radio-controlled helicopters designed by the Japanese for use in agricultural spraying would make a superb delivery system that could be launched close to the target area by special forces troops. A pickup truck driving along the perimeter road upwind of an air base or sea port on a clear night with a gentle breeze would provide a superb delivery system.

One of the primary advantages of a low-tech delivery system, such as a small truck, boat, or special forces team, is that no advance warning would be given. Because of the lack of detection equipment, there would be no evidence or warning of an attack until hours or days later, depending on the agents used. Not until people became incapacitated or began dying would there be any indication of an attack. Presumably, an enemy would coordinate the outbreak of symptoms with an actual attack by conventional weapons.

Detection and Defense

Biological agents are not dermally active and do not present a significant threat by the skin route of exposure. With advanced warning of a BW attack, protective masks and protective shelters with filtered air can be extremely effective countermeasures.

—Biological Weapons Proliferation, Defense Nuclear Agency, p. 74

While this statement is true, the full story on detection and defense is complex and considerably less positive. When America deployed 500,000 troops to Southwest Asia during the Gulf War, a theater in which there was a serious threat of attack by biological weapons, including anthrax and botulinum, the US military had no effective means of detecting an attack. There was an insufficient supply of vaccines for some agents, and for several other agents thought to be in the Iraqi arsenal, no vaccines existed. In other words, the 500,000 US personnel sent to Southwest Asia during the Gulf War had virtually no detection capability and, therefore, little defensive capability unless they wore their protective masks at all times—a virtually impossible requirement.

Despite the fact the Gulf War brought increased attention and some increases in funding for biological warfare defenses, there have been few, if any, significant improvements in defensive capabilities. The following excerpt is from the executive summary of a 1994 report by the US Army Medical Research Institute of Infectious Diseases:

The United States is ill-prepared to face a BW threat. Highly reliable, field deployable BW agent detection technologies do not yet exist, current stocks of US vaccines and medicines are inadequate to provide protection against multiple potential BW agents, and US forces and civil defense personnel are generally lacking in adequate training and other forms of preparedness for defense against biological warfare. In some cases, vaccines and/or effective therapy for a particular agent do not exist at all. Present personal protection methods developed against CW, however, are effective against BW agents, if warning of attack were given, since most BW agents would be delivered via the aerosol route. Unfortunately, there are no reliable detectors to provide timely warning of a BW attack, so it is unlikely that troops would be wearing masks at the time of the attack.

Considering the wide range of agents available for use in a biological weapons program, and the fact that vaccines for many of these agents do not exist, the probability of immunizing troops prior to a conflict is extremely low. Furthermore, even the vaccines that do exist might prove to be less than successful since they were developed to protect against a disease contacted through "normal" means (in many cases, gastro-intestinal) rather than inhalation.

This article uses the term "well-trained, well-equipped military personnel." This should not be interpreted to mean that significant amounts of additional training are needed to prepare America's armed forces for operations in a BW environment. For military personnel, operations in a BW environment requires significantly less training than would be required for operations in a chemical environment. The only individual equipment needed is a standard issue protective mask—to prevent inhalation of BW agents. In most cases, the most important BW training for military personnel can be conducted in classrooms. Understanding the nature of the threat, such as the difference between infectious and contagious agents (carrying anthrax patients on your airplane won't infect you) are critically important to maintaining discipline and effectiveness in a BW environment.

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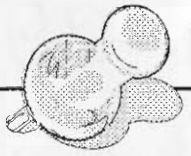

WANTED

The Command Historian of the Chemical School is seeking assistance in finding a photograph of Mr. Randolph Monro. Mr. Monro was an expert in protective masks who worked at Aberdeen in the 1930s through the early 1950s. If anyone knows of a book or magazine where Mr. Monro's picture can be found, please contact Dr. Burton Wright II, Command Historian, US Army Chemical School, ATTN: ATZH-CM-MH, Fort McClellan, Alabama 36205-5020 or phone DSN 865-5722 or commercial (205) 848-5722.