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“THE POOR MAN’S ATOMIC BOMB”?
BIOLOGICAL WEAPONS IN THE MIDDLE EAST

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PREFACE

During his tenure as dictator of Iraq, Saddam Hussein has exhibited a callous willingness to utilize terrible weapons to achieve strategic goals. His use of chemical weapons to quash domestic Kurdish dissent and against Iranian troops during the Iran-Iraq War provide ample witness to the depth of his ruthlessness. Still, the recent war in the Persian Gulf raised for the first time the specter of biological warfare in a significant way. Clearly, as the immunization of American military personnel in Saudi Arabia illustrated, the Bush Administration took seriously the biological weapons threat.

A still more ominous theme underlies Iraq's threats to exploit its unconventional capabilities. Regional bullies the world over have learned that, with military might and a reasonably credible unconventional threat, they can attain a level of "prestige" not otherwise possible. American policymakers must take this lesson into consideration as the war in the Persian Gulf gives way to postwar planning. They will undoubtedly be considering how to prevent the emergence of other aggressive garrison states.

The question of biological weapons, then, must be addressed on two levels. First, there is the problematic experience of Saddam Hussein's biological arsenal. What do we know about biological weapons and the threats the Iraqi program could have posed to the region and beyond? And

further, how can the United States be prepared to prevent and protect against their use?

The Iraqi program provides clues to tackling the second level of this threat, the proliferation of biological weapons throughout the world. What is the extent of biological weapons proliferation in the Middle East and elsewhere? And most importantly, how can American policymakers control the development and proliferation of these dangerous weapons?

In previous studies, W. Seth Carus has analyzed the proliferation of unconventional weapons and ballistic missiles in the Third World, with particular emphasis on the Middle East. This detailed understanding provides Dr. Carus with a unique background to analyze biological weapons proliferation in the Middle East and policies to curb them in the future. Toward that end, he recommends a number of policies, including a vigorous implementation of the Enhanced Proliferation Control Initiative of 1990, an international effort to strengthen the Biological Weapons Convention, assistance to nations threatened by biological weapons and development of a military response to biological weapons threats.

This Policy Paper has been made possible by a grant from the Lynde and Harry T. Bradley Foundation of Milwaukee. On behalf of The Washington Institute's Board of Trustees and Board of Advisors, I would like to express our gratitude to the Bradley Foundation for their generous support.

Dr. Carus' study comes at a singular moment in Mideast politics, when postwar planning focuses on mechanisms for achieving regional stability. The Washington Institute is proud to present this important contribution to the public understanding of biological weapons and the policymakers' efforts to control their proliferation.

Barbi Weinberg
President
March 1991

EXECUTIVE SUMMARY

The dangers of the proliferation of biological weapons have been highlighted by the conflict with Iraq. Although the evidence is scanty, it appears that Iraq has been attempting to develop an offensive biological warfare capability, and there is a possibility that it may have acquired munitions capable of delivering biological agents. Nothing is known of Iraqi delivery capabilities, making it virtually impossible to assess the potential seriousness of the current threat to allied forces or to civilians.

Because biological weapons are not known to have been used since 1945, our understanding of what it means to wage biological warfare is necessarily incomplete and based in part on theoretical calculation. It is clear that development and employment of biological weapons can be extremely difficult. As a result, it is possible that a less than effective biological weapons attack might cause few if any casualties. Yet, biological agents are sufficiently dangerous that successful employment could cause the death of thousands or even tens of thousands of people.

Existing international laws, the Geneva Protocol of 1925 and the Biological Weapons Convention of 1972, prohibit the possession or use of biological weapons. Despite the convention, however, there are growing concerns that some countries may be attempting to develop the ability to wage biological warfare. Efforts are under way to strengthen the Biological Weapons

Convention, but treaty obligations alone will be insufficient to deal fully with the problem.

Although the Biological Weapons Convention is an important part of the American biological warfare policy, also important are the Defense Department's biological defense program and nonproliferation efforts. The new Enhanced Proliferation Control Initiative may provide some of the tools needed to impose penalties on proliferating countries, but the initiative is new and has no proven track record. Accordingly, there may be room for additional measures intended to strengthen American efforts to contain biological weapons proliferation.

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I. INTRODUCTION

Saddam Hussein has claimed that Iraq possesses ballistic missiles capable of carrying biological weapons.¹ This dramatic, if ambiguous, statement only served to dramatize earlier assertions by American officials that Iraq was indeed capable of waging biological warfare. A Bush Administration decision in late 1990 to immunize U.S. troops stationed in Saudi Arabia underscored the perceived seriousness of the threat.²

As troubling as is the immediate threat from Baghdad, American officials, however, believe that Iraq is only one of a

¹In a January 28, 1991 interview given by Saddam Hussein to Peter Arnett of CNN. Hussein discussed Iraqi-made al-Hussein missiles, and claimed that "this missile is capable of carrying nuclear, chemical and biological warheads." This was understood by Arnett and others as a claim that Iraq had biological warheads for the missiles. In fact, a literal reading indicates that Hussein asserted only that the missile was "capable" of carrying such munitions, which could be nothing more than a theoretical statement of the missile's potential. Moreover, given that Iraq is not believed capable of producing nuclear warheads for its al-Hussein missiles, the claim to possess unconventional warheads could be nothing more than propaganda. In the context of the interview, however, it appears that Hussein intended to leave the impression that he could launch such weapons. In discussing possible use of unconventional warheads, Saddam said, "we pray that we shall not be forced into taking a forced measure." See the text of the interview of Saddam Hussein by Peter Arnett, CNN, released January 29, 1991.

²Michael R. Gordon, "Gulf G.I.'s to Get Germ War Shots," *The New York Times*, December 28, 1990, pp. A1, A6.

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growing number of countries, several in the Middle East, that are attempting to acquire the capacity to conduct biological warfare.

Assessing the reality of the threat posed by biological warfare, however, presents serious difficulties. It is a subject that lends itself all too easily to alarmist writings. Since 1945, there has been no confirmed use of biological warfare; thus, we have no modern precedent by which to assess the magnitude of its dangers. Earlier attempts to use biological agents, especially by the Japanese in China, were largely failures. Advances in science and technology during the past forty years have opened new possibilities for the conduct of biological warfare.³ As a result, historical experience provides little help in determining the actual threat of biological warfare.

Even with these uncertainties, the international community has attempted to ban biological weapons. The 1972 Biological Weapons Convention prohibits the development, possession, or use of biological and toxin weapons, while permitting research and development of defenses against biological agents. One hundred seven countries are full parties to the convention.⁴

Despite the Convention, concern is mounting that more countries are attempting to acquire biological weapons. The

³Recent advances in biotechnology have generated worries that it may be possible to create new agents or new forms of old agents. The most important single technological advance was the development during the 1940s and 1950s of aerosol methods for dissemination of biological agents. Aerosols consist of clouds of minute particles (liquid or dry), and (for reasons discussed in more detail below) present a considerably greater danger than other methods of spreading biological agents.

⁴The text of the convention, and a list of countries that have accepted it, are given in U.S. Arms Control and Disarmament Agency, *Arms Control and Disarmament Agreements: Texts and Histories of the Negotiations*, 1990 edition, pp. 129-141. Although 112 countries have signed the BWC, only 84 of them have ratified it. Another 23 countries deposited instruments of accession without signing the agreement. Technically, it is the 1925 Geneva Protocol, not the Biological Weapons Convention, which prohibits employment of biological weapons. The Geneva Protocol contains a provision banning the use of "bacteriological methods of warfare," which has been extended to cover all forms of biological warfare.

danger of their proliferation, and the threat they pose to the United States and its allies, require that the American government work to strengthen international safeguards to prevent their spread. But because of the immediacy of the Iraqi threat, the United States must also consider what measures it should take if biological weapons are used.

DEFINITIONS

Biological agents are living organisms capable of killing or incapacitating people, livestock, or crops.⁵ In essence, they are diseases, usually of the sort that pose public health and medical problems under natural conditions. By contrast, chemical agents are poisonous chemical substances. Toxins, whether natural or synthetic, constitute yet a third category between biological and chemical agents. Toxins are poisons that can be produced by living organisms but that would be used like chemical agents. Toxin weapons are banned under the terms of the 1972 Biological Weapons Convention, while possession of chemical agents remains permissible pending the conclusion of the Chemical Weapons Convention. Some authorities resolve the potential confusion by treating toxin weapons as a distinct category of munitions, distinct from both biological and chemical weapons. The focus of the present study is biological weapons, although toxins will be discussed in passing.

While the list of dangerous diseases is long, only a few are suitable for use as biological agents.⁶ According to a United Nations study, a potential biological agent needs to satisfy a number of relatively demanding criteria.

⁵Two authoritative studies of biological weapons were prepared by the World Health Organization and the United Nations. See World Health Organization (WHO), *Health Aspects of Chemical and Biological Weapons* (Geneva: World Health Organization, 1970) and United Nations, *Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use*, United Nations Report E.69.I.24 (New York: United Nations, 1969). The author used a copy of the U.N. study reprinted by Ballantine Books in 1970. To avoid confusion, citations of that work will reference paragraphs numbers rather than pages.

⁶A fuller examination of biological agents and their characteristics appears in Appendix I.

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The bacteriological (biological) agents which could potentially be used in warfare are far fewer than those which cause naturally occurring disease. To be effective for this purpose, they should: (a) be able to be produced in quantity; (b) be capable of ready dissemination in the face of adverse environmental factors; (c) be effective regardless of medical countermeasures; (d) be able to cause a large number of casualties (which would imply that any agent chosen would be highly infectious; but whether the agent would also be easily transmissible from man-to-man would depend upon an intent to initiate an epidemic spread).⁷

⁷U.N., *Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use*, paragraph 58.

II IRAQ AND BIOLOGICAL WEAPONS

THE PUBLIC RECORD

In recent years, there has been a growing concern that Iraq was attempting to develop biological weapons. American officials have claimed for some time that Iraq had an offensive biological warfare program.¹ CIA Director Judge William H. Webster said on September 18, 1990 that "Iraq has a sizable stockpile of chemical and biological weapons."² Congressman Les Aspin (Democrat of Wisconsin), the chairman of the House Armed Services Committee, added that Iraq "is expected to have a militarily significant biological program by the end of this year or early next year." Press reports suggested that Iraq possesses munitions "that can disperse respiratory

¹The Iraqi biological warfare program is discussed in W. Seth Carus, *The Genie Unleashed: Iraq's Chemical and Biological Weapons Program*, Policy Paper Number 14, Washington Institute for Near East Policy, 1989, pp. 29-35, and Michael Eisenstadt, "The Sword of the Arabs:" *Iraq's Strategic Weapons*, Policy Paper Number 21, Washington Institute for Near East Policy, 1990, pp. 7-8.

²From Proposed Remarks by William H. Webster, Director of Central Intelligence, at the Foreign Policy Association, New York City, September 18, 1990, p. 5.

anthrax," apparently meaning that Iraq has weapons capable of disseminating anthrax in an aerosol form.³

Similar assertions have appeared elsewhere. Former British Prime Minister Margaret Thatcher said on November 13, 1990 that, "We believe that [Saddam Hussein] also has biological weapons at his disposal."⁴ A few days earlier, Yasir Arafat reportedly suggested that Iraq possessed anthrax bombs, and that the weapons would be employed against Israel in the event of a war.⁵

Soviet officials have also suggested, somewhat cautiously, that Iraq has biological weapons.⁶ In early 1991, Col. Gen. S. Petrov, commander of chemical forces in the Soviet army, claimed, "As far as biological weapons are concerned, it is impossible to rule out the possibility that Iraq has at its disposal agents for typhus, cholera, anthrax, and tularemia, and also stocks of agents for extremely rare African and Asian diseases that are usually untreatable and lead to death."⁷ He also noted,

³Molly Moore, "Iraq Said to Have Supply of Biological Weapons," *The Washington Post*, September 29, 1990, p. A1.

⁴Quoted in *Chemical Weapons Convention Bulletin*, Issue No. 10, December 1990, p. 12.

⁵*Reuters*, November 5, 1990, citing a report in *al-Sabah*.

⁶For an example of Soviet commentary on Iraqi biological capabilities, see the interview with Colonel of the Medical Service N.Ye. Uskov, deputy chief of the Soviet Ministry of Defense Central Military Medical Directorate Sanitary and Epidemiological Department in Moscow *Krasnaya Zvezda* (Russian), January 30, 1991, p. 5, as translated in Foreign Broadcast Information Service (FBIS), *Daily Report: Soviet Union*, January 30, 1991, p. 21. He noted, "we do not have at our disposal any kind of official information to the effect that centers for the production of such [biological] weapons were located on Iraqi territory." Nevertheless, his tendency to accept the veracity of such reports is evident from a discussion of the likely consequences of attacks on biological weapons facility. Dr. Uskov argued that attacks on such facilities would cause "mass incidence of disease and epidemics among servicemen and the civilian population in Iraq." Noting that no such reports had appeared, Dr. Uskov suggested that the absence of such outbreaks implied that "it would be entirely logical to assume that preparing for war and expecting such massive strikes, the Iraqi command could have shipped out these weapons and hidden them securely somewhere."

⁷Moscow *Trud* (Russian), January 18, 1991, p. 3, as translated in FBIS, *Daily Report: Soviet Union*, January 24, 1991, p. 20. He also said, "You will

"Iraq's stockpiles of bacteriological and toxic weapons are not known."⁸ In late January 1991 another general, attached to the Soviet General Staff, reportedly told a German journalist that despite American attacks, "Iraq still has...bacteriological weapons."⁹

Since early 1988¹⁰ there have been persistent reports from U.S., West German, Iranian, Israeli, and Kurdish sources claiming that Iraq was attempting to develop an offensive biological warfare capability.¹¹ Indeed, one unidentified

understand that we cannot judge Iraq's chemical and bacteriological potential sufficiently accurately. There is too little information about this in the open press. I know the Americans also have no reliable data on this matter."

⁸Moscow *Izvestiya* (Russian), January 29, 1991, p. 4, as translated in FBIS, *Daily Report: Soviet Union*, January 30, 1991, p. 20.

⁹According to Major General Bogdanov, chief of the Center for Operational Strategic Analysis of the USSR General Staff, as quoted in Berlin *Der Morgen* (German), February 1, 1991, p. 1, as translated by FBIS, *Daily Report: Soviet Union*, February 5, 1991, p. 12.

¹⁰The first report of Iraqi biological warfare efforts appears to have been "Iraq developing germ warfare capability," *Jane's Defence Weekly*, January 9, 1988, p. 3.

¹¹The following are the sources for the allegations:

West Germany: *Hamburg DPA* (German), January 19, 1989, as translated by FBIS, *Daily Report: West Europe*, January 23, 1989, p. 11. The official cited is Friedhelm Ost. See also *The Washington Times*, January 27, 1989, p. 2. According to Thomas F. O'Boyle, "Bonn Backs U.S. Charge That Iraq Can Produce Biological Weapons," *The Wall Street Journal*, January 23, 1989, p. A11, "A top West German official ... said Bonn has vague indications to support the U.S. charge that Iraq has the capability to produce biological weapons."

Iran and the Kurds: "Kurds claim Iraq bombed city with typhoid," *New Scientist*, September 22, 1988, p. 25; Tehran IRNA (English) September 25, 1988, as reported in FBIS, *Daily Report: Near East and South Asia*, September 26, 1988, p. 62, and Con Coughlin, "New Evidence of Iraqi War," *The Sunday Telegraph*, September 25, 1988, p. 1.

Israel: Unidentified Israeli officials reportedly claimed that "We know they have developed a military biological capacity." See *The Washington Times*, January 19, 1989, p. A8.

United States: For the first official statement to name Iraq, see Statement of Rear Admiral Thomas A. Brooks, U.S. Navy, Director of Naval Intelligence, before the Seapower, Strategic, and Critical Materials

American official reportedly claimed in early 1989 that "everybody knows the Iraqis are trying to develop biological weapons."¹²

ASSESSING IRAQI BIOLOGICAL WARFARE CAPABILITIES

News reports in 1989 suggested that Iraq had been investigating a variety of well-known biological agents, including typhoid, cholera, anthrax, tularemia, and equine encephalitis.¹³ More recent stories have said that Iraq may also be working on botulin and ricin toxin, plague, West Nile fever, meningitis, and yellow fever.¹⁴ However, many such accounts suggest that Iraq has "weaponized" only two of those agents, anthrax and botulin toxin, which were among those

Subcommittee of the House Armed Services Committee on Intelligence Issues, 14 March 1990, p. 54.

¹²David Ottaway, "U.S. Gave Iraq Bacteria, Sen. McCain Charges," *The Washington Post*, January 26, 1989, p. A16.

¹³David Ottaway, "U.S. Gave Iraq Bacteria, Sen. McCain Charges," *The Washington Post*, January 26, 1989, p. A16, mentions the last three. The first two are mentioned in *The Washington Times*, January 19, 1989, p. A8.

¹⁴Malcolm W. Browne, "Army Reportedly Ready for Iraqi Germ Warfare," *The New York Times*, January 6, 1991, p. A6. See also Malcolm W. Browne, "Germ Warfare Regarded As a Hard Enemy to Fight," *The New York Times*, December 28, 1990, p. A6. Anthrax and botulin toxin are mentioned by Patrick J. Sloyan, "Germ Warfare Tactics," *Long Island Newsday*, November 8, 1990, p. 7. Plague is mentioned by the Soviets in Rick Atkinson and Barton Gellman, "Iraq Trying to Shelter Jets in Iran, U.S. Says," *The Washington Post*, January 29, 1991, p. A13. According to Glenn Frankel, "Journalists Tell How Iraqis Censored Their Reports," *The Washington Post*, February 9, 1991, p. A13, the British army was inoculating its soldiers in Saudi Arabia against bubonic plague. Meningitis and yellow fever were named by Eric Nadler and Robert Windrem, "Deadly Contagion," *The New Republic*, February 4, 1991, p. 18. Meningitis can be caused by both virus and bacteria. The most dangerous form appears to be meningococcal meningitis, a bacterial infection, which can result in 50% fatalities unless treated. See Abram S. Benenson, editor, *Control of Communicable Diseases*, 15th edition (Washington, D.C.: American Public Health Association, 1990), pp. 277-286.

standardized by the United States when it had a biological warfare program.

No information is available on Iraqi acquisition of the technology for the dissemination of biological agents. Iraq may possess equipment suitable for covert dissemination, perhaps using commercially available systems. It is difficult to estimate the suitability of such commercially available hardware for use in military delivery systems. Delivery of agent using military systems, such as missiles or combat aircraft, probably would require development of new hardware, since the necessary devices cannot be obtained off-the-shelf.

According to the press, American and foreign intelligence agencies believe that before the allied bombing Iraq possessed a research and development facility at Salman Pak, immediately south of Baghdad. According to a German press report, the Salman Pak laboratory was built for Iraq by Thyssen Rheinstahl Technik as part of Project "Diyala." The contracts were signed in 1980 and 1981, and construction was completed in 1983. The value of the contracts reached 20 million Deutsch Marks, worth about \$9 million at the time. A number of other German companies were subcontractors for the project, supplying climate control equipment, air scrubbers, and other equipment.¹⁵

A German report in late 1990 claimed that there were additional facilities in Samarra, the site of Iraq's chemical weapons manufacturing complex.¹⁶ The United States attacked several locations in January 1991 said to be related to Iraq's biological weapons program. This included one facility that Iraq claimed was an infant formula plant, but which Pentagon officials asserted was involved in the production of biological weapons.¹⁷

¹⁵*Stern* (German), No. 7, 1991, pp. 29-33A. The facility also is used for research on chemical weapons. These contracts covered construction costs only, thus excluding purchases of laboratory equipment.

¹⁶"We have Surprises," *Der Spiegel* (German), October 8, 1990, pp. 148-152, as translated by FBIS, *Daily Report: West Europe*, October 10, 1990, p. 9.

¹⁷Al Kamen, "Iraqi Factory's Product: Germ Warfare or Milk?," *The Washington Post*, February 8, 1991, pp. A1, A30. It is impossible to disentangle the truth of claims made by either country relying on open source material. Unfortunately, this seems typical of the difficulties in

In theory, Iraq could deliver biological agents using ballistic missiles, cruise missiles, or aircraft, by using either spray tanks or submunitions. Saddam Hussein has said that Iraq's missiles are capable of delivering biological agents. Biological munitions can be delivered using ballistic missiles: the United States is known to have developed biological warheads in the 1950s and 1960s for some of its own ballistic missiles, relying on submunitions that dispensed either liquid or dry agent. Although Iraq may possess the technology needed to produce a biological warhead for a ballistic missile, it seems unlikely that it would have been able to complete development of such a munition. Significantly, Israeli officials reject claims that Iraq could have biological warheads for missiles.¹⁸

Iraq is more likely to possess spray tank systems for use with aircraft or cruise missiles. It should not be difficult to develop spray tanks, possibly based on commercial systems, for use from slow flying planes or cruise missiles. The effectiveness of the air defenses arrayed against Iraq, however, suggests that it may be difficult for Iraqi aircraft to penetrate into Israel or Saudi Arabia. Even if a few might be able to penetrate into hostile territory, it is far more likely that the planes would be shot down before leaving Iraqi territory. As a result, Iraq may find this to be an unreliable means of delivery.

Iraq's capacity to use biological agents through military systems may depend on the improvisation of crude disseminating systems for cruise missiles. Iraq already possesses a large number of antiship missiles that could be adapted to this purpose. The Iraqi-manufactured Fao-200 antiship missile, a 200 kilometer (125-mile) range version of the Soviet Styx, has the range and payload to strike at a number of targets inside Saudi Arabia. This missile carries a 500 kg (1,100-pound) warhead, which could be replaced by a spray

assessing allegations of biological weapons activity. Iraq has announced that it intends to ask for a United Nations investigation. "Iraq Asks U.N. To Investigate Bombed Factory," *The Washington Post*, February 9, 1991, p. A22.

¹⁸According to Maj. Gen. Avihu Bin-Nun, Israeli Air Force commander, as quoted in *Yediot Aharonot* (Israel), and cited in *Mideast Mirror*, February 1, 1990, p. 9.

tank filled with biological agent.¹⁹ Such a missile might be able to carry 20 kg (44 pounds), or more, of biological agent, a significant amount if effectively disseminated. The range of the missiles could be extended by reducing the weight of the payload. Although this would cut down on the amount of agent delivered, it might significantly extend the number of targets that could be threatened.

Iraq might be able to convert long-range remotely piloted vehicles into cruise missiles. The Mirach 100 remotely piloted vehicles that Italy sold to Iraq could be thus adapted. This system has a one-way range of 900 kilometers (560 miles), but is designed to carry a mission payload of no more than 70 kg (154 pounds). However, the Mirach 100 is small, can operate at low altitudes, and is built with an automatic navigation system. Accordingly, it could well form the basis for a delivery system if Iraq wanted to strike at distant targets.

Iraq could also rely on covert means of dissemination, although the tight security after the outbreak of the war in the gulf doubtless increased the difficulties of such activities. Biological agents could be released from small boats off the coast of Saudi Arabia in the Persian Gulf. If the wind came from the right direction, it would threaten a host of critical military and economic installations located near the coast. Alternatively, an aerosol generator could be fitted to a truck and shipped into Saudi Arabia from a neighboring country. The operators of the truck would need to get within only miles of the intended target, depending on wind conditions. Iraq might also choose to threaten other targets. For example, terrorist teams equipped with equipment disseminating biological weapons could be dispatched to Western cities.

Although Iraq might be able to acquire systems for disseminating biological agents, there is no evidence to suggest that it presently possesses such capabilities. Accordingly, we cannot accurately assess the potential of an Iraqi biological weapons threat. Nevertheless, Iraq, as well as other countries, could obtain the delivery systems they would need to disseminate agents of biological warfare.

¹⁹Iraq also might be able to adapt Chinese-supplied Silkworm missiles, some of which are designed for air launch from H-6 medium range bombers. It is doubtful, however, that the bombers were operational following intensive strikes on Iraqi air bases.

EVALUATING THE ALLEGATIONS

Allegations of biological warfare activity by Iraq have come from a diverse group of sources, lending credence to claims that might be dismissed as mere propaganda if advanced by any single source alone. However, detailed evidence is still limited, unlike other Iraqi unconventional weapons programs. For example, a great deal is known of Iraq's chemical weapons production facilities, and the press has widely reported on Iraq's efforts to acquire technology and equipment needed to build nuclear weapons. By contrast, only a few sketchy details have emerged on activities potentially related to biological weapons development.

A report in early 1988 claimed that Iraq was making substantial purchases of pharmaceutical manufacturing equipment, and that U.S. intelligence believed that it was being used to create a biological warfare production capability.²⁰ In October 1990, a story based on German sources reported

that all over the world Saddam Hussein's purchasers are buying laboratory equipment, bacteria strains, nutrient solutions, and fermentation of bacteriological weapons.²¹

According to this account, several German companies were known to have supplied Iraq with material potentially applicable to a biological warfare program. One transaction in May 1989, for example, involved purchases by the Iraqi Ministry of Defense of "far more than 100 assorted items of serums, heating equipment, and drying closets." This apparently included a furnace that could be used to destroy toxic materials generated by a BW program. Another company, W.E.T., a firm implicated in the supply of hardware and technical services to the Iraqi chemical weapons program,

²⁰"Iraq developing germ warfare capability," *Jane's Defence Weekly*, January 9, 1988, p. 3.

²¹"We have Surprises," *Der Spiegel* (German), October 8, 1990, pp. 148-152, as translated by FBIS, *Daily Report: West Europe*, October 10, 1990, p. 9.

reportedly sold incubators and culture media to the State Establishment for Pesticide Production, a known front organization for Iraq's chemical weapons program.²²

We also know that Iraq has acquired cultures of diseases useful for a biological weapons program. The American Type Culture Collection in the United States reportedly provided seventeen different shipments of "attenuated strains of various toxins and bacteria" to the Iraqi Atomic Energy Commission. This is believed to have included tularemia. The Centers for Disease Control of the U.S. Public Health Service sent Iraq an Israeli-isolated strain of West Nile fever.²³

It must be emphasized, however, that such information does not prove that Iraq actually possesses a biological warfare program. In contrast to much of the technology needed to produce nuclear weapons, the equipment needed to produce biological agents can have many legitimate uses. Hence, the publicly documented transactions merely prove that Iraq has obtained hardware potentially suitable for biological warfare.

An examination of Iraqi activities in other areas contributes to the belief that Iraq may be pursuing biological warfare capabilities. It is important to note, however, that such indicators do not prove that Iraq possesses a biological warfare program. Nor can they indicate whether Iraq has successfully mastered the technological aspects of developing a biological warfare capacity.

First, Iraq is known to have conducted research on some of the classical biological agents, and that it possesses some of the technology needed to mass produce biological agents. Iraq has valid public health reasons for some of this activity. Some of the classical biological agents are endemic among the population of Iraq, including anthrax, brucellosis, bubonic plague, cholera, dengue fever, Q fever, tularemia, typhoid, and typhus. In 1972 Iraq reported 102 cases of anthrax, 14 cases of brucellosis, and 1,415 cases of typhoid fever.²⁴ Statistics reported

²²"We have Surprises," *Der Spiegel* (German), October 8, 1990, pp. 148-152, as translated by FBIS, *Daily Report: West Europe*, October 10, 1990, pp. 8-10.

²³Nadler and Windrem, "Deadly Contagion," pp. 18-20. Attenuated strains would not be used to produce biological agents, but could be used to develop vaccines against the diseases.

²⁴Defense Intelligence Agency, *Medical Capabilities Study: Republic of Iraq* (U), DST-1810S-456-76, pp. 20-31. Joseph S. Bermudez kindly provided the

to the United Nations for 1980 are similar: 200 cases of anthrax, 96 cases of brucellosis, 10 cases of louse-borne epidemic typhus, and 2,732 cases of typhoid and paratyphoid fevers.²⁵ Thus, completely apart from a biological weapons program, Iraq appears to have adequate cause to research these biological agents and to prepare protection against them.²⁶

Accordingly, in the mid-1970s the Veterinary Laboratory at Abu Ghurab was reported to be producing vaccines against a variety of diseases, including anthrax.²⁷ By the early 1980s, Iraq had a veterinary vaccine production and research institute at Doura, Baghdad, capable of producing up to 12 million doses per year of hoof-and-mouth disease vaccine. There was a local demand for only 2 million doses per year, suggesting that the facility's production may have been larger than was actually necessary. In 1989, Iraq combined the two facilities under the auspices of the Al-Kindi Company for Serum and Vaccine Production. The new company was authorized to produce human vaccines, and plans called for the eventual production of 15 different vaccines.²⁸

Iraq also is known to possess a drug manufacturing facility at Samarra. Originally built by the Soviets, the factory was upgraded with German assistance. The capabilities of this facility are not known.²⁹

Second, Iraq's defense forces may be able to obtain munitions needed to disseminate biological agents. Iraq is

author with the unclassified portions of this document, which he obtained through a Freedom of Information request.

²⁵World Health Organization, *World Health Statistics Annual*, 1983 (Geneva: World Health Organization, 1983), p. 376.

²⁶Such activity would raise suspicions, because it would be considerably cheaper to acquire vaccines from commercial sources.

²⁷Defense Intelligence Agency, *Medical Capabilities Study: Republic of Iraq*, p. 56.

²⁸*Middle East Economic Digest*, February 10, 1989, p. 15, and *Middle East Economic Digest*, June 27, 1987, p. 16.

²⁹*The Middle East and North Africa 1988*, 34th edition (New York: Europa Publications, 1987), pp. 434-435, and *Middle East Economic Digest*, August 29, 1987, p. 10.

already known to have employed chemical-filled aircraft bombs, artillery shells, and artillery rockets. It may now possess ballistic missile warheads for chemical agents as well.³⁰ Iraq also claims to produce fuel air explosives, technically a difficult achievement. In addition, Iraq can produce cluster munitions for delivery by aircraft bombs, artillery shells, and artillery rockets.³¹

More important than indigenous capabilities, however, has been Iraq's ability to exploit foreign technology. There is substantial evidence to suggest that Iraq was able to acquire the services of foreign companies to provide components, technology, and production facilities for the production of military hardware.³² An Iraqi biological warfare program might well follow a similar pattern.

If this thesis is correct, it is reasonable to expect to discover that foreign expertise played a central role in Iraqi efforts to acquire biological warfare capabilities. It is likely that components even for munitions were manufactured by foreign companies.

Third, a biological warfare program would be consistent with Iraq's broader efforts to acquire strategically important weapons capabilities, particularly unconventional weapons. It is known to have acquired chemical weapons and ballistic

³⁰Eisenstadt, *"The Sword of the Arabs: Iraq's Strategic Weapons"*, p. 7, note 7.

³¹Guy Willis, "Open Sesame!: Baghdad Show Reveals Iraqi Military-Industrial Capabilities," *International Defense Review*, June 1989, pp. 837-838, for cluster munition warheads for the Ababil 100 rockets, the Eagle aircraft-delivered cluster bombs, and air-delivered fuel air explosives. "Rocket projects continue," *Jane's Defence Weekly*, May 20, 1989, p. 926, reports on a cluster munition warhead for the FROG-7s in Iraqi inventories. "Saddam 122mm towed howitzer," *Jane's Defence Weekly*, May 20, 1989, p. 927, reports on the production of a 122mm cluster munition artillery shell.

³²There is considerable evidence to suggest that Iraq acted in this fashion in a large number of different areas. For a discussion of some of these activities, see Kenneth R. Timmerman, "The Poison Gas Connection: Western Suppliers of Unconventional Weapons Technology to Iraq and Libya," a special report commissioned by the Simon Wiesenthal Center, Los Angeles, California, 1990, pp. 3-25. Many of the people working for Iraq were quite skilled, as with Gerald Bull, the Canadian ballistics expert who helped the Iraqis on a variety of projects.

missiles, and is seeking to produce nuclear weapons. Moreover, it has made great efforts in a broad range of research and development projects, ranging from naval mines to airborne early warning aircraft.³³

ALLEGATIONS OF USE

Kurdish sources claim that Iraq has already employed biological weapons, by introducing typhoid into the water supply of the Kurdish city of Al-Sulaymaniyah in 1988. As evidence of Iraqi responsibility for this act, Kurdish doctors claim that only one strain of typhoid was discovered, and that during natural epidemics, more than one strain of the disease can be identified, and that other waterborne diseases (such as cholera) would normally appear at the same time.³⁴ Other Kurdish sources have claimed that biological agents were used in 1987 against Kurds in Al-Sulaymaniyah and Arbil, as well as in evacuation camps created by the Iraqis for Kurds relocated from their traditional villages. According to these accounts, a large number of refugees were killed by the contamination of water supplies at the camp of Al-Qasri, outside Arbil, with typhoid and cholera.

The current regime in Iraq has a long history of use of poisons against known or suspected adversaries. The Iraqis have used chemical agents against the Kurds on a massive scale, killing perhaps thousands of people. In addition, there are many documented cases of use of thallium to poison dissidents. It is believed that some nerve-agent variety of a chemical was used to poison large numbers of Kurdish refugees in Turkey.³⁵ This pattern of conduct lends some

³³There is now an enormous literature on Iraq's activities. A useful overview appears in Eisenstadt, *"The Sword of the Arabs: Iraq's Strategic Weapons."*

³⁴"Kurds claim Iraq bombed city with typhoid," *New Scientist*, September 22, 1988, p. 25; Tehran IRNA (English) September 25, 1988, as reported in FBIS, *Daily Report: Near East and South Asia*, September 26, 1988, p. 62, and Con Coughlin, "New Evidence of Iraqi War," *The Sunday Telegraph*, September 25, 1988, p. 1.

³⁵Middle East Watch, *Human Rights in Iraq* (New Haven: Yale University Press, 1990), pp. 56-58 (thallium poisoning), 75-85 (chemical weapons

credence to the suggestion that Iraq may well have used biological agents, as well.

Allegations such as these should be taken with some skepticism, until additional supporting evidence becomes available. Claims that biological weapons have been used have been made in other conflicts, and in all cases the allegations proved to be false. Given that typhoid and cholera are endemic to Iraq, it is possible that disruptions in medical care and public health services resulting from the Iran-Iraq War led to natural outbreaks of these diseases.³⁶ And, even if Iraq did, in fact, spread diseases in Kurdish areas, it would not provide any hard evidence of biological warfare capabilities, since waterborne diseases can be spread relatively easily without requiring sophisticated technical capabilities.³⁷

IRAQI DENIALS

During 1989 and 1990, Iraqi officials vehemently denied that their country had sought to acquire biological weapons.³⁸ President Saddam Hussein told a group of U.S. Senators in April 1990 that

I have said Iraq has no biological weapons, because Iraq is aware of the danger of toying with this issue. As to whether scientists have done research on this or that

employment against the Kurds), and 94-96 (employment of organophosphorous poison against Kurdish refugees in Turkey). Kurdish officials claim that 700 refugees were killed in Turkey. Thallium is a soft metal often used as a rat poison. See Vienna *Wiener Zeitung* (German), June 25, 1989, p. 1, as translated by FBIS, *Daily Report: Near East and South Asia*, June 29, 1989, p. 10.

³⁶According to one source, U.S. officials were aware of the Kurdish claims of biological weapons use by Iraq, but had no independent confirmation of the reports. See Stephen Engelberg, "Iraq Said to Study Biological Arms," *The New York Times*, January 18, 1989, p. A7.

³⁷The author is indebted to Milton Leitenberg for clarifying some of these issues, based on his investigations of earlier allegations of biological weapons use.

³⁸A denial by Iraq's ambassador to the United States is reported in David B. Ottaway, "Official Denies Iraq Has Germ Warfare Plant," *The Washington Post*, January 19, 1989, p. A36.

sort of germ, I do not give a guarantee in this matter,
and I do not deny it.³⁹

In 1991, Saddam Hussein appeared to contradict his earlier assertion by claiming that Iraq possessed missiles capable of carrying biological warheads. However, the statement was ambiguous at best, and does not necessarily constitute a change in position.

³⁹ Baghdad Domestic Service (Arabic), April 16, 1990, as translated in FBIS, *Daily Report: Near East and South Asia*, April 17, 1990, p. 7.

III IRAQI THREATS TO U.S. FORCES

Following the American response to the Iraqi invasion of Kuwait in August 1990, the threat posed by Iraqi biological weapons assumed an immediate importance for the United States. The United States faced a military opponent who might be capable of waging biological warfare. With the start of the war in January 1991, these concerns became particularly acute.

When the fighting came to an end, however, no attempt had been made to employ biological agents. Given the limited amount of publicly available information, it remains difficult to assess the real threat posed by Iraqi biological weapons endeavors. It is virtually impossible to determine even if Iraq was capable of waging biological warfare.

It is possible that Iraq had not initiated production of biological munitions before the war. Alternatively, coalition air strikes on storage and production facilities might have destroyed Iraq's entire stockpile of biological weapons. Finally, Iraq may have retained an inventory of biological weapons despite the attacks, but decided for political reasons not to employ them.

According to American officials, "we have destroyed his [Hussein's] biological production and storage capability. That's not to say that he couldn't have something in the field somewhere, but he doesn't have any back home."¹ This

¹ Lt. Gen. Tom Kelly, Director for Operations, Joint Staff, at the Defense Department Regular Briefing, February 22, 1991.

suggests that even American officials were uncertain about the exact status of Iraqi biological weapons capabilities.

Iraq's failure to employ chemical munitions further complicates the picture. We know Iraq had chemical weapons and was capable of using them. Yet, it now appears that Iraq deployed none of its chemical weapons in the Kuwaiti theater of operations.² This suggests that Iraq would not have used biological weapons, even if it had an operational capability.

Assuming that Iraq had the ability to employ biological weapons, several critical questions must be addressed, none of which can be answered satisfactorily. First, under what circumstances did Iraq intend to employ these weapons? Second, if Iraq possessed biological weapons, how was it likely to employ them? Third, how did the United States respond to the threat of biological warfare?

IRAQI BEHAVIOR

We simply do not know under what circumstances Iraq intended to employ biological warfare. Several factors gave cause for concern. Iraq's extensive use of chemical weapons in the Iran-Iraq War was a disturbing precedent: it suggested that Iraq might employ biological weapons, if it thought that the benefits of using them outweighed the costs. There were fears that Iraq would turn to biological warfare if it were on the verge of catastrophic defeat. In addition, Saddam Hussein might have chosen to employ biological agents if he thought that it would undermine the willingness of the United States to continue the war against him. Given the allies' assumption that Iraq would employ chemical agents during a ground war, it appears that we badly misunderstood Iraqi motivations.

In retrospect, it seems that Saddam Hussein was hesitant to use unconventional weapons, despite threats that seemed to indicate the contrary. Apparently, he believed that employing such weapons might have adverse implications for his long-term survival. At the present time, however, too little is known to assess confidently his motivations. Ultimately, all that can

² Rick Atkinson, "No Chemical Arms Found on Battlefield," *The Washington Post*, March 7, 1991, pp. A1, A35.

be said is that if Iraq possessed biological weapons, there was some chance that it might have employed them.

IRAQI CAPABILITIES

It is equally difficult to know exactly how Iraq might have conducted biological warfare. Estimates of Iraqi capabilities are largely conjectural. If Iraq were capable of disseminating biological agents, it is likely that it would have had to rely on relatively crude delivery systems. This would have significantly limited the military effectiveness of the biological munition.

Iraq probably had no long-range delivery capabilities. It is unlikely to have possessed a biological warhead for the medium range Al-Husayn missiles. Iraq might have been able to develop a crude aircraft-delivered bomb, but such a munition would have been largely ineffective. It also might have possessed aircraft delivery systems, such as spray tanks, but it is unlikely that aircraft operating such equipment could have survived in the presence of coalition air defenses. Although spray tanks could be installed on cruise missiles or remotely piloted vehicles, there is no evidence to suggest that Iraq had developed such systems. The absence of a dependable long-range delivery capability would have forced Iraq to depend on unreliable terrorist operations in order to mount biological warfare attacks on civilian targets in Israel or Saudi Arabia.

Iraq probably would have been limited to tactical employment of biological agents. For example, it could have spread biological agents using truck-mounted aerosol generators, assuming that the wind were blowing in the right direction (toward enemy military forces). This would have been extremely risky, because Iraqi troops could have been victimized by agents spread in this manner.

Even if Iraq had been capable of disseminating biological agents, the air defense capabilities of Iraq's enemies and the likely technological inadequacies of Iraq's dissemination methods significantly limited the potential threat.

RESPONSES BY THE UNITED STATES

False expectations of chemical weapons use make it clear that there was little understanding of the forces that influenced Iraqi behavior. The United States government attempted to deter Iraqi use of such weapons by threats of retaliation. Unfortunately, it was difficult to believe that Saddam Hussein would be impressed by such threats. Given the intensity of the conventional strikes being mounted against Iraqi strategic targets, threats of conventional escalation would have only marginal impact on Iraq's conduct of the war. Even a threat to employ nuclear weapons would be of little value, because Saddam Hussein might well doubt American willingness to resort to such weapons.

It is likely that the only true deterrent against Iraqi use of biological weapons was a threat to radically expand the allied objectives in the conflict. Specifically, Saddam Hussein might have hesitated to use biological weapons because he believed the result would be an allied decision to continue fighting until he was removed from power. Such a fear might have given him reason to defer turning to his biological weapons arsenal. Unfortunately, if Iraq were faced with catastrophic defeat, such considerations might mean little to Hussein. It is thus unclear to what extent the United States influenced Baghdad's decisions.

The fact that deterrence may not have been able to prevent Iraqi employment of biological weapons posed serious problems for the United States. Specifically, it forced the American military to depend largely on the protection afforded by its biological defense capabilities. However, biological defenses, including vaccines, protective gear, and post-infection medical treatment may indeed be sufficient to cope with the consequences of a biological weapons attack.³

³ Biological defenses are discussed in greater detail in Appendix III.

IV THE EXTENT OF THE PROLIFERATION OF BIOLOGICAL WEAPONS

The threat of Iraqi biological warfare, while arguably the one of greatest immediate importance, is by no means the only such threat, either in the Middle East or elsewhere in the world. In 1986, the Defense Intelligence Agency expressed the view that

In recent years, we have become increasingly concerned that this genre of weaponry [biological] will be developed by some nations including those of the third world. We are gravely concerned that we will see biological warfare programs underway in some countries within five years and limited production within a decade.¹

In 1989, a senior U.S. intelligence official warned that, "at least ten countries are working to produce both previously known and futuristic biological weapons."² At about the same time, a U.S. Army intelligence analyst testified that, "the number of nations having or suspected of having offensive biological and

¹Defense Intelligence Agency, *Soviet Biological Warfare Threat*, DST-1610F-057-86, 1986, p. iii.

²Judge William H. Webster (Director of Central Intelligence), "Chemical Weapons Give the Poor Man's Answer to Nuclear Armaments," *The Officer*, June 1989, p. 7.

toxin warfare programs has increased from four to ten since 1972.” He added that, “some of these nations are unfriendly to the U.S.; some are located in the Middle East; and some are signatories to the BWC [Biological Weapons Convention].”³ By implication, some of the countries may be friendly to the United States, some are located outside the Middle East, and others are not parties to the Convention.

No complete list of alleged biological warfare proliferators has been made public, although certain countries have been officially identified as possessing a biological weapons program. For many years, the United States government has asserted that the Soviet Union has been conducting offensive biological weapons research.⁴ In 1988 the Office of Naval Intelligence told a committee of the House of Representatives that Taiwan, North Korea, and the People’s Republic of China were “involved in biological warfare programs.”⁵ In early 1990, the same agency identified the Soviet Union, Syria, and Iraq as countries with biological warfare capabilities.⁶ In June 1990, Secretary of Defense Dick Cheney reported that among the 10 countries that “have, or may have, biological warfare programs” were Iran, Iraq, Syria, Libya and North Korea.⁷ Thus, the United States has identified publicly eight countries

³Testimony of Dr. Barry J. Erlick, Senior Biological Warfare Analyst, U.S. Army, before the United States Senate Governmental Affairs Committee and the Permanent Subcommittee on Investigations, February 9, 1989.

⁴Defense Intelligence Agency, *Soviet Biological Warfare Threat*, 1986, p. v., for a 1986 report.

⁵Statement of Rear Admiral William O. Studeman, U.S. Navy, Director of Naval Intelligence, before the Seapower and Strategic and Critical Materials Subcommittee of the House Armed Services Committee on Intelligence Issues, 1 March 1988, p. 48. Admiral Brooks also notes that “others are suspected.”

⁶Statement of Rear Admiral Thomas A. Brooks, U.S. Navy, Director of Naval Intelligence, before the Seapower, Strategic, and Critical Materials Subcommittee of the House Armed Services Committee on Intelligence Issues, 14 March 1990, p. 54. According to Admiral Brooks, these countries were “assessed as having these capabilities [biological warfare], and others are suspected of having it.”

⁷UPI, June 11, 1990.

thought be engaged in biological weapons-related activity: China, Iran, Iraq, North Korea, Libya, the Soviet Union, Syria, and Taiwan.

In addition to these public pronouncements, unidentified U.S. officials reportedly have stated that Iraq, Israel, Syria, and Libya have biological weapons programs. According to one account in early 1989, a State Department official claimed that Israel and Syria had biological weapons programs more advanced than Iraq's, and that Libya was in the process of developing such weapons.⁸

Similar allegations have been made by other governments as well. The governments of Britain, Iran, Israel, the Soviet Union, and Germany have supported the American belief that Iraq has an offensive biological warfare program. A West German government spokesman suggested in early 1989 that Libya also may be engaged in such activity.⁹ Iraq's President Saddam Hussein charged in early 1989 that Israel possessed biological weapons, as had Egyptian President Anwar Sadat in 1972.¹⁰

A few countries have admitted to having an interest in biological weapons. Before Egypt signed the Biological Weapons and Toxin Convention in 1972, Egyptian officials claimed to possess biological agents intended for offensive

⁸Robin Wright and William C. Rempel, "U.S. Finds Iraq Has Germ War Plant," *The Los Angeles Times*, January 18, 1989, p. 6.

⁹"Bonn on Libyan Research," *The Washington Post*, January 20, 1989, reports that a West German government spokesman said, "There are indications that Libya could also be intending to carry out biological research" at a proposed microbiology institute.

¹⁰Baghdad Domestic Service (Arabic), April 16, 1990, as translated in Foreign Broadcast Information Service, *Daily Report: Near East and South Asia*, April 17, 1990, p. 7. On the Egyptian claims, see Stockholm International Peace Research Institute [SIPRI], *The Problem of Chemical and Biological Warfare*, Volume II (New York: Humanities Press, 1973), p. 241.

use.¹¹ More recently, a senior Iranian official suggested in 1988 that his country intended to begin a program.¹²

Other countries have declared that they are conducting defensive research on biological warfare research. While denying American allegations that it intends to manufacture biological weapons, Taiwan nonetheless admits that it will "conduct research on defense against attack of biochemical weaponry."¹³ Similarly, one Brazilian official reported that his country was conducting research into defenses against biological weapons, adding that,

This does not mean we will manufacture chemical or bacteriological weapons, but we want to study their effects to develop antidotes, just as radiation must be studied to develop radiation protection.¹⁴

In addition to the claims made by official sources, allegations have appeared that Bulgaria,¹⁵ Cuba,¹⁶ Romania,¹⁷

¹¹According to President Anwar Sadat, as quoted in SIPRI, *The Problem of Chemical and Biological Warfare*, Volume II, p. 241.

¹²Hojjat o-Eslam Akbar Hashemi-Rafsanjani, then speaker of the Iranian Majlis, in Tehran IRNA (English), October 19, 1988, as reported in FBIS, *Daily Report: Near East and South Asia*, October 19, 1988, pp. 55-56.

¹³Taipei CNA (English), October 28, 1989, in FBIS, *Daily Report: China*, October 30, 1989, p. 73.

¹⁴Paulo Motta, *O Globo* (Portuguese), September 29, 1990, p. 21, as translated by FBIS, *Daily Report: Latin America*, September 25, 1990, p. 40, quoting General Romero Lapesqueur, Army science and technology secretary, in reference to the activities of the Institute for Special Projects (IPE) of the Army Technological Center (Cetex).

¹⁵Harvey J. McGeorge, "Chemical Addiction," *Defense and Foreign Affairs*, April 1989, p. 19. Bulgaria may be included because of its use of ricin in assassination attempts against Bulgarian dissidents living in Western Europe. For a discussion of these episodes, see Robert Harris and Jeremy Paxman, *A Higher Form of Killing: The Secret Story of Chemical and Biological Warfare* (New York: Hill and Wang, 1982), pp. 197-198. It is possible, however, that the weapons used by the Bulgarians in these attacks could have been supplied by the Soviets.

¹⁶John Barron, "Castro, Cocaine and the A-Bomb Connection," *Reader's Digest*, March 1990, p. 70, claims that Cuba has a program to develop

and South Africa,¹⁸ have or have had biological weapons programs.¹⁹ The Cuban and South African stories were based on rumors or stories told by defectors. In contrast, the Rumanian report comes from a former Rumanian government official who claimed to have personal knowledge of the alleged activities.

EVALUATING THE CLAIMS

Allegations of offensive biological warfare activities have been made concerning fourteen countries in all—Bulgaria, China, Cuba, Egypt, Iran, Iraq, Israel, North Korea, Libya, Romania, South Africa, the Soviet Union, Syria, and Taiwan. No information is available in the publicly available literature that would definitively confirm any of the claims.

It is inherently difficult to monitor biological warfare programs, even for those with access to sophisticated information gathering means. Satellite imagery is of limited value, because it cannot be used to discover the details of

biological weapons, citing a Cuban source (who dates the information to 1982) and an unnamed U.S. intelligence official.

¹⁷Lt. Gen. Ion Mihai Pacepa, *Red Horizons* (Washington, D.C.: Regnery Gateway, 1987), pp. 111 and 120, claims that Rumania had a program to develop biological weapons. According to this account, by a former chief of Rumanian intelligence, the first agent produced by this project was brucellosis. No dates are given, but it appears that the account refers to a period in the early to mid 1970s. The author also claims that Rumania also worked on a "bacteriological missile."

¹⁸Special Committee on the Situation with Regard to Implementation of the Declaration on the Granting of Independence to Colonial Countries and Peoples, United Nations, General Assembly, "Military Activities and Arrangements by Colonial Powers in Territories Under their Administration which might be Impeding the Implementation of the Declaration of Granting of Independence to Colonial Countries and Peoples," A/AC.109/781, July 31, 1984, p. 12.

¹⁹In some cases, unofficial sources have expressed allegations similar to the ones given by official sources. For example, McGeorge, "Chemical Addiction," *Defense and Foreign Affairs*, p. 19, includes a chart that lists Bulgaria, Cuba, Iran, Iraq, Israel, Libya, North Korea, Syria, and the Soviet Union among countries with "confirmed use or stockpiling" of biological agents in the 1980s.

research being conducted in laboratories inside buildings. Biological warfare research and production relies on equipment with legitimate civilian uses, and a laboratory engaged in nefarious research may appear identical to one involved in more benign activities. As a result, facilities required to research biological warfare or to produce biological agents may have no distinctive identifying features, making it impossible to demonstrate the purpose of the work being performed inside of them. Thus, human intelligence is essential for obtaining reliable information.²⁰

Even if it were possible to ascertain that a country is unequivocally engaged in biological warfare-related activities, it could well be conducting legitimate defensive research. The line between prohibited offensive and permissible defensive research is often unclear, given that developing defenses can require research into the characteristics of the offensive capabilities to be protected against. Thus, a country may appear to be pursuing a range of suspicious actions while never violating the 1972 Convention.²¹

The unique character of biological weapons further complicates their detection. It may not be necessary to stockpile vast quantities of biological agents in order to have a viable offensive capability. Although some agents can, in fact, be preserved in quantity with little difficulty, the ability quickly to grow large quantities of any given agent renders it unnecessary. As a result, a strategic biological warfare capability could consist of nothing more than small vials of selected agent stored within a production plan.

The difficulty in proving allegations has important implications for U.S. policy: particular care must be taken when evaluating claims that a country possesses a biological warfare program. It is easy to make allegations, but they may be impossible to prove absent public declarations, the disclosure

²⁰For a thorough discussion, see Raymond A. Zilinskas, "Verification of the Biological Weapons Convention," pp. 82-107, in Erhard Geissler, *Biological and Toxin Weapons Today* (New York: Oxford University Press for Stockholm International Peace Research Institute, 1986).

²¹Some of the complexities inherent in discriminating defensive from offensive biological warfare research are discussed in Milton Leitenberg, "Research and Development in (C) BW," an unpublished paper.

of detailed intelligence information, or demonstrated employment.

Assuming that the publicly available list of countries engaged in offensive biological warfare research is substantially correct, several interesting, albeit tentative, observations can be made. First, the number of countries engaged in biological weapons proliferation is half as long as the list of countries believed to have chemical warfare programs. American officials claim that twenty or more countries have or are suspected of having an offensive chemical weapons capability.²²

It also appears that every country believed to be developing biological weapons also is on the list of proliferating chemical weapons states.²³ This appears to confirm the suspicions of some analysts that the two types are linked, at least at the policy level. This lends support to the belief that prevention of chemical warfare programs provides an important—perhaps even essential—firebreak against biological weapons proliferation.²⁴

²²Most recently, Secretary of Defense Dick Cheney put the number at 23. See *UPI*, June 11, 1990.

²³The list of potential chemical weapon proliferants varies from one source to another. For a careful exploration of this subject, see Elisa D. Harris, "Appendix 2: Chemical Weapons Proliferation: Current Capabilities and Prospects for Control," pp. 67-87, in *Aspen Strategy Group, New Threats: Responding to the Proliferation of Nuclear, Chemical, and Delivery Capabilities in the Third World*, Aspen Strategy Group and University Press of America, 1990. The only country mentioned as a possible BW state that is not routinely identified as a CW state is Cuba. The source of the claims for Cuban BW activity, John Barron, "Castro, Cocaine and the A-Bomb Connection," *Reader's Digest*, March 1990, p. 70, claims that it is working on nerve agents as well. Thus, the credibility of both allegations are linked.

²⁴This linkage was suggested in United Nations, Security Council, S/18852, "Report of the Specialists Dispatched by the Secretary-General to Investigate Allegations of the Use of Chemical Weapons in the Conflict Between Iran and Iraq," May 8, 1987, p. 6, which states that "if the [Geneva] Protocol [banning first use of chemical weapons] is irreparably weakened after 60 years of general international respect, this may lead, in the future, to the world facing the specter of the threat of biological weapons."

V THE EFFECTIVENESS AND UTILITY OF BIOLOGICAL WARFARE

Determining the utility of biological weapons is a difficult subject and, not surprisingly, a controversial one. The absence of historical experience on which to base an analysis of the use of biological weapons, makes it necessary to rely on untested theoretical models and on studies of uncertain validity. This uncertainty is compounded by compelling evidence that using biological weapons is itself inherently difficult. According to a study group assembled by the World Health Organization (WHO),

The possible effects of chemical and biological weapons are subject to a high degree of uncertainty and unpredictability, owing to the involvement of complex and extremely variable meteorological, physiological, epidemiological, ecological, and other factors.¹

Even a cursory examination of the problems of dissemination of biological agents confirms this view. For example, biological agents are subject to biological decay. Some organisms are likely to disappear almost entirely a few minutes after their

¹World Health Organization, *Health Aspects of Chemical and Biological Weapons* (Geneva: World Health Organization, 1970), p. 11.

release into the air. In addition, biological agents are destroyed by ultraviolet rays: they are killed when exposed to the sun.²

Skilled scientists and engineers may be able to overcome many of the technical difficulties associated with biological weapons. Although the margin of uncertainty associated with biological weapons may be great, it does appear possible to produce, store, transport, and disperse biological agents. Moreover, if properly developed and disseminated, biological weapons could be lethal.

Evaluating the utility of biological weapons, however, depends only to a limited extent on the technical aspects of dissemination of the agents. Equally important are a variety of tactical and strategic considerations. There are widely divergent views on the military or strategic utility of biological weapons. Just before the United States ratified the Biological Weapons Convention in 1972, Fred Ikle, then Director of the Arms Control and Disarmament Agency testified that,

the military utility of these weapons is dubious at best; the effects are unpredictable and potentially uncontrollable, and there exists no military experience concerning them. Hence, the prohibitions of this [biological weapons] convention do not deny us a militarily viable option....³

This view, reflecting the official American policy at the time, seems to be limited to an evaluation of the tactical value of biological weapons on the battlefield.

Other authorities, however, are less dismissive, arguing that biological warfare is a potentially devastating form of war.

Biological weapons employing infectious agents pathogenic to man have the potential to kill or incapacitate populations over large areas. This potential derives from the extreme smallness of the amount of agent sufficient to initiate infection. Delivered by aircraft, missile, or other means and dispersed near

²Some of the factors that complicate efforts to disseminate biological agents are discussed in greater detail in Appendix II.

³United States Senate, Committee on Foreign Relations, *Prohibition of Chemical and Biological Weapons*, 93rd Congress, 2nd session, December 10, 1974, p. 15.

the ground as wind-borne aerosols to be inhaled by a target population, certain infectious agents could in theory approach the anti-personnel effectiveness of thermonuclear warheads, in terms of the weight of the agent and associated dissemination devices required to attack a given area.⁴

According to this view, biological weapons may be extremely dangerous if used against cities, suggesting that a country intent on killing enemy civilians might find biological weapons a useful means of doing so.

An increasing number of experts, both in the United States and elsewhere, are concerned that the potential utility of biological weapons has been heightened by technological developments, particularly the advances in biotechnology of the last two decades. Another source of concern is the widespread availability of equipment capable of mass production of biological agents and the general commercialization of systems that could be used to disseminate agents.⁵

Despite these concerns, it is still widely believed in the United States that biological weapons have no military utility. This perspective appears to be based in part on a misinterpretation of the rationale that led the United States to abandon biological weapons. It is unclear whether other countries, facing radically different strategic circumstances, would make the same decision.

Three factors appear to have influenced the prevailing American assessment of the utility of biological warfare. First, the United States already possessed a nuclear arsenal, eliminating the need for biological agents as weapons of mass destruction. Second, the possession of nuclear weapons provided a retaliatory capability against biological warfare,

⁴Matthew Meselson, Martin Kaplan, and Mark A. Mokulsky, "Verification of Biological and Toxin Weapons Disarmament," p. 150, in Francesco Calogero, Marvin L. Goldberger, and Sergei Kapitzka, eds., *Verification—Monitoring Disarmament* (Boulder, Colorado: Westview, 1990).

⁵An elaboration of this view appears in Erhard Geissler, "New assessments of the potential value of BW and TW agents," pp. 15-21, in Geissler, ed., *Strengthening the Biological Weapons Convention by Confidence-Building Measures*, SIPRI Chemical and Biological Warfare Studies No. 10 (New York: Oxford University Press, 1990).

making it unnecessary to acquire biological weapons as an in-kind deterrent. Third, biological warfare was an unpredictable, unreliable tactical weapon, significantly reducing its military utility.⁶

Although it was recognized that biological weapons were unpredictable, it does not appear that the United States decided that biological weapons were ineffective or had no utility, under any circumstances. Indeed, it appears that the American position was adopted in part in direct response to the perceived dangers of biological warfare. The Nixon Administration came to believe in 1969 that it made no sense to continue development of biological warfare technology, when other countries were likely to be the primary beneficiaries.

Assessments of the utility of any particular form of warfare can be problematic. They depend as much on national strategies and military doctrines as on the technical capabilities of the weapon under evaluation. As a result, it is thus unclear whether the arguments that led the United States to abandon its own biological weapons program would apply with equal force to other countries, especially those in the third world. Few third world countries possess nuclear arsenals, and those that do appear to have only small inventories. As a result, countries that wish to be able to kill people in large numbers might well seek to acquire biological weapons.

Specifically, there may be four objectives that could motivate a country to acquire offensive biological capabilities: as a deterrent against an opponent's use of unconventional weapons, as a strategic weapon, as a tactical weapon, and as an instrument of sabotage and terror.

DETERRENCE

Some third world countries are known to view biological warfare as a necessary deterrent against the potential hostile employment of biological weapons. Iran's current President, Hojjat o-Eslam Akbar Hashemi-Rafsanjani, has said, for

⁶Elisa D. Harris, "The Biological and Toxin Weapons Convention," pp. 191-219, in Albert Carmesale and Richard Haass, editors, *Superpower Arms Control: Setting the Record Straight* (Cambridge, Mass.: Ballinger Publishing Co., 1987).

example, that he considers biological weapons to be essential for this reason.

Chemical and biological weapons are a poor man's atomic bombs and can be easily produced. We should at least consider them for our defense...Although the use of such weapons is inhumane, the [Iran-Iraq] war taught us that international laws are only drops of ink on paper.⁷

According to this view, molded by Iran's experience with Iraqi employment of chemical weapons, a country threatened by an attack of biological weapons needs to acquire its own arsenal of them in order to threaten retaliation.

This contemporary Iranian view is remarkably similar to one expressed by President Anwar Sadat of Egypt in 1972.

The only reply to biological warfare is that we too should use biological warfare. I believe that the density of the Israeli population confined in a small area would provide the opportunity to reply with the same weapon if they should be using it. Briefly, we have the instruments of biological warfare in the refrigerator and we will not use them unless they begin to use them.⁸

From this perspective, biological warfare is not a desired instrument of war fighting; but it is, however, essential to prevent its use by an enemy.

TACTICAL AND OPERATIONAL UTILITY

According to conventional wisdom, biological weapons cannot be employed tactically. Biological agents require time to take effect, because of the incubation period between the time of infection and the time symptoms begin to appear. The

⁷Tehran IRNA (English), October 19, 1988, as reported in FBIS, *Daily Report: Near East and South Asia*, October 19, 1988, pp. 55-56.

⁸As quoted in Stockholm International Peace Research Institute [SIPRI], *The Problem of Chemical and Biological Warfare*, Volume II (New York: Humanities Press, 1971), p. 241.

incubation time depends on the disease and the size of the exposure. Tularemia takes two to ten days, although this can be reduced by exposure to extremely heavy concentrations. Anthrax has an incubation period of two to seven days, but the initial symptoms of inhalatory anthrax are quite mild and it may take several days before it incapacitates.⁹ Thus, biological weapons are of limited value in circumstances requiring an immediate response to hostile military activity.

Biological agents disseminated in militarily effective doses also can pose a severe hazard to the forces of the country that has dispersed them. Depending on wind conditions and the amount of agent released, a cloud could travel tens of kilometers before the agent it contains becomes ineffective. As a result, dissemination under the wrong conditions could lead to infection of friendly troops. It is possible, of course, to immunize one's own troops against biological agents, but exposure to extremely heavy concentrations of infectious agents can overwhelm even the protection afforded by vaccines.¹⁰ For these reasons, the tactical employment of biological weapons is problematic.

Finally, biological agents have the potential of thoroughly contaminating an area. This could pose problems to a country using biological weapons if it intended subsequently to occupy the area under biological attack. Moreover, negative political and strategic consequences resulting from such an outcome easily could outweigh any tactical value that biological weapons might offer.

Nevertheless, it would be a serious mistake to assume that biological agents have no tactical utility. Indeed, there are circumstances under which they could have considerable operational value, even if they are less useful in an immediate tactical sense. Forces stationed in rear areas are obvious targets. This could include reserve combat units, formations massing

⁹Abram S. Benenson, editor, *Control of Communicable Diseases*, 15th edition (Washington, D.C.: American Public Health Association, 1990), pp. 18, 467; and Rothschild, *Tomorrow's Weapons*, pp. 207, 243.

¹⁰WHO, *Health Aspects of Chemical and Biological Weapons*, p. 76, reports that people immunized against tularemia contracted the disease when exposed to the equivalent of 1,000 infective doses. Vaccination may reduce death rates under such circumstances, but large numbers of people still would be incapacitated.

behind the lines in preparation for an offensive, or air force squadrons. Biological weapons might also be aimed at rear area support units. The benefits of incapacitating command and control, intelligence, and logistics units are clear. Without such units, the fighting effectiveness of any modern military force would be significantly reduced.¹¹

Attacking targets tens or hundreds of kilometers inside enemy territory minimizes risks to friendly forces. A strike against such units need not produce immediate results, but would begin significantly to reduce an army's overall fighting capabilities within a few days. A country with biological weapons capabilities could find biological agents of considerable military utility if its leaders believed that it might take more than a few days to defeat an adversary using other means.

Thus, it would appear that biological weapons could be militarily useful in situations when immediate results are not required and where the danger to friendly forces is minimal. Thus, even if biological warfare has only slight immediate value on the battlefield, it could have considerable utility when directed at rear area units.

STRATEGIC

For many years, American biological warfare experts considered biological agents primarily as strategic weapons.

¹¹The only attempt to assess the military utility of biological weapons for third world countries is provided by Raymond A. Zilinskas, "Biological Warfare and the Third World," *Politics and the Life Sciences*, August 1990, pp. 59-76. Zilinskas argues that biological warfare is unlikely to be attractive to third world countries, and suggests that is the reason only one third world country (Iraq) is known to have such a program. As indicated here, there are suggestions of considerably greater activity than that, implying greater perception of the potential utility of biological weapons than Zilinskas admits. Zilinskas argues that biological weapons have limited tactical utility, but fails to appreciate the important distinction between the tactical and operational levels of war (as discussed here). He also argues that it is unlikely to be used in the opening stages of a conflict when an attacker may expect to achieve a quick, decisive victory. Although this may be true for the attacking side (although it would depend on the expectations of easy victory, which might not always be present), it certainly would not apply to a disadvantaged defender.

The very factors that can make biological weapons problematic from a tactical point of view are significantly less important at the strategic level. The incubation period is of limited concern in a context in which it may be possible to wait days or even weeks before the desired results are achieved. Similarly, the fact that these agents can disperse over wide geographic areas—a side-effect that can be detrimental to a country's own forces in the field—can be a positive benefit when attacking cities or other large areas.¹²

Although it can be difficult to effectively disseminate biological agents, there is reason to believe that biological warfare has the potential for killing very large numbers of people. Authorities consulted by the World Health Organization concluded that,

If a biological agent such as anthrax were used, an attack on a city by even a single bomber disseminating 50 kg [110 pounds] of the dried agent in a suitable aerosol form would affect an area far in excess of 20 km², with tens to hundreds of thousands of deaths.¹³

The WHO experts developed a simple model to estimate casualties that could result from a biological attack on a city. According to their calculations, an attack using only 50 kg pounds of anthrax against a city of one million in a developing country could kill 95,000 people.¹⁴ Such an attack could be mounted on a single aircraft or cruise missile.

Some countries might seek biological weapons as a “poor man’s atomic bomb,” especially if faced with acute external threats. Those with aggressive ambitions might view biological weapons as a means of furthering their political goals. Given that biological weapons are most suitable for attacks on large areas, and for use against unprotected populations, biological weapons programs seem well suited as weapons of mass

¹²For a typical example of this view, see LeRoy D. Fothergill, “Biological Warfare and Its Defense,” *Armed Forces Chemical Journal*, September-October 1958, p. 4.

¹³WHO, *Health Aspects of Chemical and Biological Weapons*, p. 19.

¹⁴WHO, *Health Aspects of Chemical and Biological Weapons*, pp. 98-99.

destruction.¹⁵ They could supplement nuclear capabilities or could act as an interim weapon of mass destruction for countries still in the process of achieving a nuclear capacity.

Biological weapons might thus be particularly attractive for third world countries. Producing biological munitions almost certainly would be less expensive than acquisition of nuclear weapons. Public health and medical systems in the third world are often inadequate, and could easily be overwhelmed by such a health catastrophe.

There exist potential dangers in using biological warfare as a strategic weapon, but the risks can be minimized. For example, selection of agents that are not communicable from one person to another can largely eliminate the danger of starting an epidemic that could backfire on the population of the attacking nation. None of the agents standardized by the American biological warfare program was contagious.¹⁶

SABOTAGE AND TERROR

Biological agents can be used as instruments of sabotage and terror. Toxins have been used in assassinations. The Bulgarians used them in a handful of attacks on emigre dissidents in the late 1970s, including the notorious assassination of Georgi Markov. It has been alleged that the British used botulinum toxin in the successful assassination of Reinhard Heydrich, the Nazi official in charge of Czechoslovakia.¹⁷ The U.S. Central Intelligence Agency

¹⁵Zilinskas, "Biological Warfare and the Third World," p. 72, argues that biological weapons are unlikely to be used against cities, except by "a particularly ruthless leadership." Yet, chemical weapons have been used in that way by Iraq and more than one nuclear power has publicly discussed targeting of cities. There is no reason third world countries should be less ruthless than the major nuclear powers.

¹⁶This included such diseases as anthrax, brucellosis, Q fever, tularemia, and Venezuelan equine encephalomyelitis (VEE). See U.S. Army Activities in the U.S. *Biological Warfare Programs*, Volume 2, p. D-2, in U.S. Senate, Committee on Human Resources, Subcommittee on Health and Scientific Research, *Biological Testing Involving Human Subjects by the Department of Defense*, 1977, 95th Congress, First Session, 1977, p. 102.

¹⁷Robert Harris and Jeremy Paxman, *A Higher Form of Killing: The Secret Story of Chemical and Biological Warfare* (New York: Hill and Wang, 1982), pp. 88-94, 197-198.

developed biological warfare agents for a variety of covert purposes, including assassination.¹⁸

There are reports, not all confirmed, of use of biological weapons of sabotage in both World Wars. During the First World War, the Germans employed anthrax and glanders against livestock in France, Romania, and the Soviet Union, as well as against animals being transported to Europe from the United States (before its entry into the war) and Argentina.¹⁹ Japanese sources claim that Soviet agents covertly employed biological agents against them in Manchuria in the 1930s.²⁰ Similarly, Soviet and Polish resistance groups are reported to have infected German troops with diseases during the Second World War.²¹

Some analysts believe that biological agents might be a weapon of choice for terrorists seeking a weapon of mass destruction.²² Biological agents could be spread using relatively simple means. In one set of tests, a simulated agent was dispersed in a subway by dropping light bulbs filled with the agent onto the tracks. The movement of the trains through the tunnels quickly dispersed the biological agent through the

¹⁸As reported in U.S. Senate, *Biological Testing Involving Human Subjects*, pp. 243-256.

¹⁹SIPRI, *The Problem of Chemical and Biological Warfare*, Volume I, pp. 216-217. For incidents involving the United States, not mentioned in the SIPRI report, see Jules Witcover, *Sabotage at Long Tom: Imperial Germany's Secret War in America, 1914-1917* (Chapel Hill, North Carolina: Algonquin Books of Chapel Hill, 1989), pp. 93, 126-127, 136-137, 238.

²⁰Peter Williams and David Wallace, *Unit 731: Japan's Secret Biological Warfare in World War II* (New York: Free Press, 1989), p. 63. The authors of this history are skeptical of the veracity of the Japanese claims.

²¹See Leo P. Brophy, Wyndham D. Miles, and Rexmond C. Cochrane, *The Chemical Warfare Service: From Laboratory to Field* (Washington, D.C.: Office of the Chief of Military History, U.S. Army, 1959), p. 114.

²²Zilinskas, "Biological Warfare and the Third World," pp. 71- 72. Some of the reasons for taking a more skeptical view appear in Raymond A. Zilinskas, "Terrorism and Biological/Toxin Weapons: Inevitable Alliance?," a paper presented at the AAAS Annual meeting, January 17, 1989.

entire subway line, exposing thousands of people to heavy doses within minutes.²³

Terrorist organizations, however, may have some problems with biological agents. Transporting and disseminating biological agents is certain to be more difficult than using more traditional weapons, such as plastic explosives. Moreover, specially trained operatives would be required. As a result, terrorists may be reluctant to deal with the uncertainties inherent in biological weapons.

²³Leonard A. Cole, *Clouds of Secrecy: The Army's Germ Warfare Tests Over Populated Areas* (Totowa, New Jersey: Rowman and Littlefield, 1988), pp. 65-69.

VI IMPLICATIONS FOR U.S. POLICY

American policy on biological weapons is based on four complementary positions. First, the United States has unilaterally committed itself to biological disarmament. Second, to encourage other countries to follow this course, the United States has engaged in multilateral biological disarmament through the Biological Weapons Convention. Third, to protect the United States and American military forces from potential biological warfare, a Biological Defense Research Program was created by the Department of Defense. Finally, the United States has worked to prevent the proliferation of biological weapons capabilities through export controls and sanctions, such as the new Enhanced Proliferation Control Initiative. These approaches are sound, and should be continued.

The considerations that led President Nixon to abandon biological weapons remain compelling today. The United States can rely on its nuclear and conventional capabilities for deterrence, even against biological threats, and has no need for biological weapons to supplement existing offensive capabilities.

The potential spread of biological warfare capabilities, however, makes it necessary to concentrate on reducing the biological threat to the United States through nonproliferation and defense efforts. In the nonproliferation sphere, the United States should redouble its efforts to encourage compliance with the Biological Weapons Convention, while, at the same time, taking actions to inhibit potential biological weapons programs.

The Convention and nonproliferation policies are related efforts to reduce the prospects for biological weapons proliferation. The Convention provides a framework within which diplomacy on biological weapons disarmament can take place. Biological nonproliferation was not a high priority until late 1990, when the Bush Administration adopted the Enhanced Proliferation Control Initiative. This initiative will enable the American government to control exports directed to countries thought to be engaged in prohibited biological warfare activities and to authorize the imposition of sanctions against such countries.

Finally, the Biological Defense Research Program is an important military response to biological weapons proliferation. The existence of a defense program could reduce the appeal of biological weapons, by demonstrating that the United States and its allies can protect themselves against such weapons. At the same time, should biological weapons be used to threaten the United States or its allies, the capabilities of the defense program ensure the existence of appropriate protection against such threats.

ENHANCED PROLIFERATION CONTROL INITIATIVE

Toward the end of 1990, the Bush Administration announced the "Enhanced Proliferation Control Initiative". This initiative imposes export controls on the technology necessary to produce chemical and biological weapons, as well as sanctions on countries intent on making use of such weapons. The initiative was launched because "proliferation of chemical and biological weapons constitutes an unusual and extraordinary threat to the national security and foreign policy of the United States."¹

As a result of these concerns, the Bush Administration adopted Executive Order 12735. The order introduces several new elements into the effort to inhibit the proliferation of biological weapons. First, it imposes controls on the export of technology related to the development and production of biological weapons. Second, it provides for the American government to apply sanctions on foreign and domestic

¹Executive Order 12735.

companies that make technology available to proliferating countries. Finally, it allows the government to impose sanctions on countries that use, prepare to use, or develop, produce, or stockpile biological weapons.

Under terms of the order, the government will “prohibit the export of any goods, technology, or services” that “would assist a foreign country in acquiring the capability to develop, produce, stockpile, deliver, or use” biological weapons. Only countries that have entered into bilateral or multilateral agreements to prevent the spread of biological agents would be exempted from these provisions.

The executive order permits the government to impose sanctions against foreign companies that assist in the development of biological weapons. Companies engaged in such activities would be prohibited from selling to the government, and could be prohibited from exporting products to the United States.

Finally, if the Secretary of State determines that a country has engaged in prohibited activities, the government is authorized to halt foreign aid, oppose economic assistance provided through multinational lending institutions, deny government credits or loan guarantees, embargo arms sales, prohibit exports to the country, and stop imports from the country.

If vigorously implemented, the Enhanced Proliferation Control Initiative would significantly strengthen efforts by the government to fight the proliferation of biological weapons. Although controls and sanctions cannot prevent proliferation in all cases, they can accomplish two important objectives. First, they can raise the cost of acquiring biological weapons. Second, they emphasize the importance of stopping the spread of biological weapons in American foreign policy.

STRENGTHEN THE BIOLOGICAL WEAPONS CONVENTION

The United States should do all it can to strengthen the Biological Weapons Convention. As it stands today, the Convention makes biological weapons one of the few weapons systems that the international community has agreed to prohibit. This is significant for several reasons. First, it reduces

the number of countries likely to acquire biological weapons. Only outlaw nations are likely to violate the convention, limiting the extent of proliferation to those countries willing to flout international agreements. Second, it provides a basis on which to act against countries known to possess biological weapons. The Convention provides legitimacy for responses against those employing biological weapons. Thus, it is the foundation upon which a policy of nonproliferation of biological weapons must be built.

Unfortunately, the Convention has weaknesses.² It has no provisions to fund a standing Secretariat, unlike the nuclear Non-Proliferation Treaty or the proposed Chemical Weapons Convention. Thus, there are no procedures for handling even routine matters. Consideration should be given to establishment of a permanent working staff, especially if the Convention is strengthened.

The Convention also lacks procedures for verifying compliance, or for investigating possible violations of the it.³ The United Nations General Assembly, however, has authorized the U.N. Secretary General to investigate allegations of biological weapons use. Experience with similar investigations of Iraqi employment of chemical weapons suggests that these procedures can be effective. Unfortunately, these U.N. procedures cannot be used to investigate allegations that a country is engaged in the development of offensive biological warfare capabilities.

It may be possible to correct some of these deficiencies at the Convention's Third Review Conference, scheduled for September 1991. This conference is important for two reasons. First, it will provide a forum for the international community

²Proposals to strengthen the Convention are given in Federation of American Scientists, "Proposals for the Third Review Conference of the Biological Weapons Convention," *Report of the Federation of American Scientists Working Group on Biological and Toxin Weapons Verification*, October 1990.

³For a discussion of the problems and prospects for biological weapons verification, see Matthew Meselson, Martin Kaplan, and Mark A. Mokulsky, "Verification of Biological and Toxin Weapons Disarmament," in Francesco Calogero, Marvin L. Goldberger, and Sergei Kapitza, eds., *Verification—Monitoring Disarmament* (Boulder, Colorado: Westview, 1990).

to reiterate its support for the principles of the Convention. Second, the agenda of the conference is expected to include proposals to strengthen the convention, including preliminary steps toward adoption of provisions for verification.

Ultimately, the United States should support efforts to adopt procedures for challenge inspections. A useful model might be those being developed for the proposed Chemical Weapons Convention. Challenge inspections would consist of intrusive examination of suspected facilities. An agreement to permit inspection of suspect facilities is likely to enhance confidence in the efficacy of the Convention. At the same time, if a country fails to permit inspections, its refusal would provide an indication that a country may be in violation of the agreement. Such a measure would significantly strengthen the hand of those attempting to take action against proliferating countries.⁴

While efforts to enhance verification are important, we should acknowledge that it is impossible to guarantee that no violations take place. No matter how rigorous the verification procedures, the large number of facilities around the world potentially capable of engaging in biological warfare research make it impossible to provide complete assurance of compliance. The proposed Chemical Weapons Convention contains provisions for monitoring of facilities considered capable of producing chemical agents. Large chemical plants are needed to manufacture chemical agents on a massive scale. The same is not true for biological agents. As a result, it is unlikely that such procedures would be of equal benefit for verification of the Biological Weapons Convention. Accordingly, efforts should be made to identify proposals that strengthen verification without imposing unacceptably burdensome reporting and inspection requirements on those engaged in legitimate activities.

⁴The Federation of American Scientists, "Proposals for the Third Review Conference of the Biological Weapons Convention," p. 6, suggests the existing authorization allowing the U.N. Secretary-General to investigate allegations of use be extended to look "into compliance concerns that do not entail use."

DETERRENCE THROUGH ASSISTANCE

Article VII of the Convention encourages assistance to countries threatened by attacks of biological weapons. The United States may wish to provide such assistance. The United States maintains a large and sophisticated biological defense program, which works closely with countries throughout the world. Providing countries with access to defensive systems, including protective clothing and masks, biological agent identification kits and vaccines, could have widespread benefits. First, it might decrease the perceived value of biological weapons if a country knew that its adversary had access to the best available defenses. Second, it could eliminate some of the opposition to the American biological defense program.

Ideally, the United States should express its willingness to make its biological defense capabilities available to any country, including even hostile nations like Iran or Vietnam. However, it might be appropriate to limit our efforts only to countries that we believe are not engaged in their own offensive biological weapons research. This could provide an incentive for countries to comply with the provisions of the convention, and reduce their desire to adopt biological weapons for retaliatory purposes.

THE MIDDLE EAST AND THE BIOLOGICAL WEAPONS CONVENTION

The Middle East poses special problems for the Biological Weapons Convention in particular and for efforts to prevent the proliferation of biological weapons in general. Several countries in the Middle East are not full members of the convention. Israel has not signed the convention, and Egypt, Iraq, Syria, and the United Arab Emirates have signed but not ratified it. In addition, many of the countries suspected of developing biological weapons are located in the Middle East, including Egypt, Iran, Iraq, Israel, Libya, and Syria.

The military confrontation with Iraq has highlighted the importance of the proliferation of biological weapons in the Middle East. These programs could constitute a direct threat to American military forces, as well as to those of the allies.

For these reasons, the United States should consider regional-specific initiatives intended to reduce the danger of proliferation biological weapons in the Middle East.

First, the United States should launch diplomatic initiatives to encourage full participation in the Convention by all countries in the Middle East. This should include efforts aimed at Israel and the Arab states alike.

Securing Israeli compliance with the convention may be difficult under current circumstances. Allegations of offensive biological warfare activity on the part of several of Israel's potential military adversaries, including countries that have signed the Biological Weapons Convention, are unlikely to convince Israeli policymakers of the virtues of the agreement. At the same time, Israeli unwillingness to join the Convention, coupled with suggestions that it possesses its own offensive biological capabilities, tends to undermine the legitimacy of Israeli concerns that it might be the victim of an attack of biological agents.

Israel seems unlikely to use biological agents against an adversary, suggesting that joining the agreement would impose only a minimal cost. Although Israeli officials may believe that an ambiguous posture might deter employment of biological weapons against it, the value of an offensive biological deterrence capability is unclear given Israel's recognized nuclear arsenal. At the same time, Israel's current position imposes costs. The Israeli failure to comply with the Convention provides a justification for its hostile Arab neighbors not to become full members of the convention.

Israeli compliance with the Convention could be conditioned on full ratification by Egypt, Iraq, and Syria. Indeed, Israel could announce its intention to join the convention, but stop short of accession pending similar action by the Arab countries. Moreover, even after joining the Convention, the Israelis could still continue their defensive biological warfare research.

Convincing Egypt, Iraq, and Syria to ratify the convention should also receive a high priority. Egypt is particularly important in this regard. It is difficult to understand Egypt's failure to ratify the convention. Given that Egypt was willing to become a full member of the nuclear Non-Proliferation Treaty, despite Israel's refusal to do so, Cairo should have little problem becoming a full member of the Convention. Because of its

position of leadership in the Arab world and its active participation in international arms control efforts, Egyptian actions would carry considerable weight.

Obtaining Syrian and Iraqi compliance may be more problematic, but the possibilities should be investigated after the war is over. Full Arab acceptance of the Convention would enhance the agreement's moral and political legitimacy. It would strengthen efforts both in the Middle East and beyond to delegitimize biological weapons.

Although full Arab and Israeli participation in the Convention would ensure that all countries in the region accept identical obligations, it would not address Israeli concerns regarding the offensive biological warfare activity of countries like Syria and Iraq. The United States needs to deal with allegations of biological warfare activity by countries in the region. This suggests a need either to consider enhanced verification procedures during the Third Review Conference, or regional-specific initiatives for mutual inspection of suspect facilities.

MILITARY DETERRENCE

Although the Biological Weapons Convention may be the foundation of U.S. policy, it cannot solve all the problems posed by the potential of threats of biological warfare. As the war with Iraq has demonstrated already, the proliferation of biological weapons increases the risk that the United States may find itself in a military confrontation with a country possessing biological weapons. This means that the United States needs to develop military responses to the threat of biological weapons.

Two questions are of particular concern. First, how can the United States deter the use of biological weapons? Second, if a country does employ biological weapons against the United States or its military forces, how should the United States respond? Clearly, the answers to these questions are intertwined, since the likely response to biological weapons employment will influence the calculations of a potential attacker.

Deterrence of biological attacks is possible only if potential users believe that the costs of employing biological weapons outweigh the benefits. This can be accomplished by

minimizing the rewards of using such weapons through defensive measures, as well as by increasing the costs by an articulated retaliatory response. This suggests that a biological defense program constitutes an essential component of any biological warfare deterrent. Retaliatory options, however, pose certain problems. The retaliatory strikes must outweigh the perceived value of the biological weapons attacks. If the attacks inflict relatively few casualties, then it might be possible to rely on massive conventional strikes. Such a response may be inadequate, however, if a large number of people are killed by biological weapons. Under such circumstances, the degree of damage inflicted by conventional retaliation may be insufficient to provide a credible deterrent. Some might argue that proportionate response would require employment of nuclear weapons if a biological attack killed thousands or tens of thousands of people. Military planners could argue that the option to use nuclear weapons should not be excluded, if only to raise doubts about the wisdom of using biological weapons.

CONTINUE THE BIOLOGICAL DEFENSE RESEARCH PROGRAM

For more than forty years, the United States has conducted research into defenses against biological agents. As a result of this work, vaccines, protective gear, and agent identification kits have been developed. In addition, the research has ensured that the United States has a group of people and organizations intimately familiar with potential biological threats. This capability is an important part of the American biological warfare deterrent.⁵ This defense program has been subjected to intense attacks. Critics claim that it is impossible to defend against biological weapons, and as a result military-controlled

⁵Justifications for the U.S. biological warfare defense efforts appear in Stanley L. Wiener, "Strategies of Biowarfare Defense," *Military Medicine*, January 1987, pp. 25-28, David L. Huxsoll, Cheryl D. Parrott, and William C. Patrick III, "Medicine in Defense Against Biological Warfare," *Journal of the American Medical Association*, August 4, 1989, pp. 677-679, Charles F. Dasey "Medical Benefits of the Biological Defense Research Program," *Politics and the Life Sciences*, August 1990, pp. 77-84, and Thomas R. Dashiell, "The Need for a Defensive Biological Research Program," *Politics and the Life Sciences*, August 1990, pp. 84-92.

biological warfare research raises concern that the program may be engaged in prohibited offensive research. Some argue that American research into defenses against biological agents may encourage other countries to acquire biological weapons.⁶ The program has also come under scrutiny as following allegations that funds had been misdirected, including some unjustified complaints by the General Accounting Office that the Department of Defense had conducted unnecessary research.⁷

However, recent events in the Persian Gulf suggest that the danger of the proliferation of biological weapons justifies the efforts of the Department of Defense to research biological defenses. Experience provides ample reason to doubt that civilian organizations could adequately respond to military needs. Thus, to the extent that biological defenses are necessary, some portion of the program must be under the control of the defense establishment.

⁶See Jay A. Jacobson and Barbara Hatch Rosenberg, "Biological Defense Research: Charting a Safer Course," *Journal of the American Medical Association*, August 4, 1989, pp. 675-676, and Robert J. Rutman and Harry J. Disch, "Commentary on Articles by Charles F. Dasey and Thomas R. Dashiell on the Biological Defense Research Program," *Politics and the Life Sciences*, August 1990, pp. 117-121. Rutman and Disch appear to believe that the only rationale for the biological defense program is the concern over genetic engineering, and ignore the work done on biosensors, vaccines, and agents that existed prior to recent advances in biotechnology.

⁷U.S. General Accounting Office, *Biological Warfare: Better Controls in DOD's Research Could Prevent Unneeded Expenditures*, GAO/NSIAD-91-68, December 1990. This report, highly critical of the research program, is ultimately unconvincing. The report never addresses the possibility that the intelligence community list of validated threats may be incomplete, or that some agents might become threats in the future. It is also claimed that duplication exists between research by civilian organization, such as the National Institutes of Health (NIH) and the Centers for Disease Control. Yet, the report only documents that those agencies are doing research related to particular agents, not that the actual research is duplicative. Based on the criteria of the GAO report, if NIH was researching a particular disease, there would be no reason to conduct any research on it at any other location. The absurdity of the position is self-evident.

APPENDIX I BIOLOGICAL AGENTS

The criteria for a successful biological agent are highly demanding, as was made clear in 1964 by the U.S. Army.

REQUISITES OF BIOLOGICAL AGENTS

(a) General. Certain requirements must be met by organisms or substances if they are to be effective biological agents. Additional characteristics that will enhance their value under varied conditions of use are desirable. The selection of a particular biological agent will be governed not only by the effect desired but also by the agent's characteristics and its ability to withstand environmental conditions. All these conditions cannot usually be fulfilled by any one agent; therefore, in making a selection, some compromise may have to be made between characteristics ranging from optimal to minimal desirability.

(b) Requirements. The agent should meet certain requirements for use against personnel, domestic food and draft animals, or plants. It should: (1) Consistently produce a given effect (death, disability, or plant damage). (2) Be manufacturable on a large scale. (3) Be stable under production and storage conditions, in munitions, and during transportation. (4) Be capable of efficient dissemination. (5) Be stable after dissemination.

(c) Desirable characteristics. Additional agent characteristics that are desirable but not required are the following: (1) Possible for the using forces to protect

against. (2) Difficult for a potential enemy to detect or protect against. (3) A short and predictable incubation period. (4) A short and predictable persistency if the contaminated area is to be promptly occupied by friendly troops. (5) Capable of: (a) Infecting more than one kind of target (for example, man and animals) through more than one portal of entry. (b) Being disseminated by various means. (c) Producing desired psychological results.¹

Relatively few diseases are capable of meeting more than a few of these criteria. Among the diseases sometimes considered suitable for use as biological agents are diseases such as anthrax, brucellosis, Q fever, tularemia, and Venezuelan Equine Encephalomyelitis (VEE).²

Anthrax is a bacterium that can form an inert spore. An anthrax spore is highly resistant to destruction, and can survive for decades. Although anthrax commonly causes diseases through ingestion of infected food or through contact with the skin, the most dangerous symptoms occur when anthrax enters the lungs. At least 70 to 80 percent of the people who contract inhalatory anthrax will die. According to one estimate, the infective dose is 20,000 spores. Anthrax does not spread among or between people. Because of its hardness and potential lethality, anthrax has been studied as a potential biological agent since the 1930s.

Brucellosis is an incapacitating disease. The disease can last for days, weeks, or even months, causing fevers, headaches, depression, and exhaustion, and weight loss. It has

¹According to U.S. Departments of Army and Air Force, *Military Biology and Biological Agents*, Departments of Army and Air Force manual TM 3-216/ AFM 355-56, March 12, 1964, as quoted by Stockholm International Peace Research Institute [SIPRI], *The Problem of Chemical and Biological Warfare*, Volume II (New York: Humanities Press, 1971), p. 311.

²The discussion that follows is based on Abram S. Benenson, editor, *Control of Communicable Diseases*, 15th edition (Washington, D.C.: American Public Health Association, 1990), J.H. Rothschild, *Tomorrow's Weapons* (New York: McGraw Hill Book Company, 1964), United Nations, *Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use*, United Nations Report E.69.I.24 (New York: United Nations, 1969), and World Health Organization, *Health Aspects of Chemical and Biological Weapons* (Geneva: World Health Organization, 1970). These sources should be consulted for more detailed information.

an incubation period of one to four weeks. Only 1,000 organisms are needed to cause an infection. Fatality rates are low, generally less than 2 percent, but some forms of the disease are more lethal. Use of aerosols to transmit the disease could result in higher death rates.

Q fever is highly infectious, but rarely kills. Symptoms include chills, fever, loss of appetite, and headaches. The incubation period is estimated at 18 to 21 days, but can be reduced by exposure to extremely large doses. According to some estimates, a single organism can cause an infection. Even in the absence of treatment, the fatality rate is less than one percent. Q fever is rarely transmitted from one person to another.

Tularemia generally is considered an incapacitating agent, but certain strains can be relatively deadly. Some sources put the lethality rate at only 5-10 percent, but inhalation can lead to forms of the disease that might kill 60 percent of those infected. According to some estimates, aerosol delivery would result in the infection of about half those exposed. The incubation period is generally about 3 days. The disease lasts for several weeks. Inhalation of tularemia can cause pneumonia. The U.S. tularemia strain is the most virulent of those known. The organism cannot be transmitted directly between people.

Venezuelan Equine Encephalomyelitis (VEE) is a virus. It can be disseminated in aerosol form, and will cause infection in about half of those exposed in this way. The incubation period is 2 to 6 days. Fatality rates are low, and recovery requires no more than about three weeks. The disease causes symptoms similar to influenza, including vomiting, headaches, pains, chills, and fevers. The most severe symptoms last for about a week.

APPENDIX II DISSEMINATION OF BIOLOGICAL AGENTS

PRODUCING AND STORING BIOLOGICAL WARFARE AGENTS

It is generally agreed that many biological agents are easy to produce in commercially-available equipment used in the manufacture of pharmaceuticals. This point was made by William H. Webster, director of the Central Intelligence Agency.

The equipment used to produce biological warfare agents is truly dual use in nature. With currently available technology, biological warfare agents can be produced at such a rate that stockpiles are no longer necessary. There are no precursor chemicals or equipment that can be used only for the production of biological warfare agents. Actually, any nation with a modestly developed pharmaceutical industry can produce biological warfare agents, if it so chooses.¹

Storing biological agents, however, can be a problem. Like all living organisms, agents die over time. Efforts have been

¹Statement of the Honorable William H. Webster, Director, Central Intelligence Agency, before the U.S. Senate Committee on Governmental Affairs Hearings on Global Spread of Chemical and Biological Weapons: Assessing Challenges and Responses, February 9, 1989, pp. 3-4.

made to extend the storage life of biological agents, through proper manipulation of the environment in which it is stored. One widely employed technique is freeze-drying, which is commonly used to store organisms over extended periods of time, but the length of the storage life depends on the particular agent. According to one source, anthrax can be stored for years, brucellosis for several months, and Q fever for up to eight years.²

METHODS OF DISSEMINATION

Biological agents can be disseminated in various forms. Many diseases are transmitted in a state of nature by insects, and efforts have been made to duplicate this process with assistance from man. Several countries developed an ability to breed insects, infect them with biological warfare agents, and then release the infected insects in enemy territory. The inherent unpredictability of reliance on insects, however, significantly reduces the attractiveness of this approach.

Biological agents also can be dispersed from military munitions. By the early 1950s, it was evident that aerosols were the most effective method of biological weapons dissemination. Aerosols are clouds consisting of very small liquid droplets or dry particles. Under natural conditions, microbes almost always appear in clumps composed of a large number of cells. It is common to find the organisms adhering to other matter, including dust or lint. In contrast, single cells rarely appear. An artificially created aerosol, however, could permit the creation of a cloud of particles consisting of single bacterial cells.³ An aerosol can be created from a biological agent in either a wet or a dry form. The dry form consists of freeze-dried organisms.

Dissemination of agents in an aerosol form, which can be inhaled, makes it possible to avoid the natural defenses of the body. According to one study, almost all particles larger than

²J.H. Rothschild, *Tomorrow's Weapons* (New York: McGraw Hill Book Company, 1964), pp. 206-219.

³William M. Creasy, "Biological Warfare," *Armed Forces Chemical Journal*, January 1952, p. 18, provided a clear discussion of the perceived importance of aerosols.

10 microns are filtered out of the air by the respiratory system. (A micron is 1/25,000 of an inch—a red blood cell has a diameter of about 7 microns). Only 50 percent of particles of 1 to 5 microns in size penetrate as far as the lungs. Further filtering takes place in the lungs. As a result, the danger posed by biological agents is significantly reduced if released in particles of greater than 5 microns, although infections can result from particles caught in the upper respiratory tract. An individual anthrax bacillus can be 3 to 8 microns long and 1 to 1.2 microns wide.⁴

The implications of the size of individual particles have been shown in research on animals. Only 3 tularemia cells were needed to infect guinea pigs when disseminated in 1 micron particles. When the particle size was increased to 7 microns, the number of cells required to cause infection increased to 6,500. And when the particles were 22 microns in size, 170,000 cells were needed. Similar results have appeared in studies of other potential biological agents.⁵

Spreading diseases through artificially-generated aerosols can have dangerous medical consequences. Some agents, including yellow fever, are normally transmitted by mosquitoes, and the diseases are not contracted through the air. As a result, aerosol transmission can lead to symptoms that do not normally appear in nature. When natural transmission occurs through the air, it is not unusual to find that infections contracted through the lungs result in the most lethal forms of the diseases caused by an agent. Anthrax contracted through the skin is fatal in only between 5 and 20 percent of the cases. When inhaled, however, it is lethal at least 70 to 80 percent of the time.⁶

⁴A.B. Christie, *Infectious Diseases: Epidemiology and Clinical Practice*, 4th edition (New York: Churchill Livingstone, 1987), Volume 2, p. 983.

⁵These figures refer to the number of cells required to kill half of the animals exposed. A similar study involving monkeys led to somewhat different results, largely due to the different structure of the lungs of the animals: 17 cells (1 micron), 240 cells (7 microns), and 3,000 cells (22 microns). Research cited in Maj. William D. Sawyer, "Airborne Infection," *Military Medicine*, February 1963, pp. 90-92.

⁶J.H. Rothschild, *Tomorrow's Weapons* (New York: McGraw Hill Book Company, 1964), pp. 198-199, 206-207, and WHO, *Health Aspects of Chemical and Biological Weapons*, p. 75.

Creating a biological aerosol is not difficult. Even before the Second World War, French scientists were investigating the use of aerosols for such applications. Today, no specialized technology is needed, because commercially-available hardware is capable of producing biological warfare aerosols. Research has indicated that many potential biological agents can be disseminated in aerosol form, including anthrax, tularemia, plague, Q fever, and Venezuelan equine encephalomyelitis.⁷

Although easy to accomplish, creation of an aerosol is destructive of the agent being released. According to one estimate, generating a liquid biological aerosol will kill 95 percent of the organisms released. This applies both for cluster bomblets, which rely on explosive dispersion, and for aerosol generators that produce fogs or clouds of biological agent.⁸

The problems only begin with the release of the organisms. The settling rate of extremely small particles poses a serious obstacle to effective distribution of biological agents. Small particles drop through the atmosphere at relatively slow speeds, and the smaller the particle the slower the rate. Biological agents released in small particles at an altitude of only 100 feet would take between 35 hours and 12 days to reach the ground, assuming that the air was still.⁹

In practice, however, the movement of a biological agent is determined by air currents. This involves both horizontal and vertical activity. The direction and speed of the wind determines horizontal movement. In essence, the area covered by a biological agent is determined by the actions of the wind. If carelessly employed, an agent released over enemy forces

⁷Maj. William D. Sawyer, "Airborne Infection," *Military Medicine*, February 1963, pp. 91-92.

⁸WHO, *Health Aspects of Chemical and Biological Weapons*, p. 94. Lt. Col. William S. Gochenour, "Aerobiology," *Military Medicine*, February 1963, p. 88, assumes that 10% of the organisms form particles of less than 6 microns. On the other hand, Defense Intelligence Agency, *Soviet Biological Warfare Threat*, p. 4, claims 100% of dry anthrax spores can be put into aerosol form, compared with only 10% for wet spores.

⁹This example is taken from Gochenour, "Aerobiology," pp. 86-87. The slowest settling rate was for the smallest particles, which were 1 micron in size, the fastest settling rate for larger particles of 5 microns.

could end up in friendly territory. According to one authority, "vertical mixing is of the greatest importance" in evaluating the effects of a biological attack. Under certain common atmospheric conditions, known as lapse conditions, there are energetic upward and downward flows of air. In such situations, "vertical mixing is so accelerated as to dissipate the aerosol as it is generated." In contrast, during temperature inversions, air is trapped near the ground and a cloud dissipates slowly.¹⁰

In addition, microbes are subject to biological decay. Microbes begin to age and die in relatively short periods of time. In some cases, the decay rate can be as high as 30 percent per minute. As a result, some biological agents will disappear because of natural causes only minutes after release into the atmosphere.¹¹ Similarly, the ultraviolet radiation present in sunlight will kill bacteria. As a result, one authority has argued that the "airborne life of many microbial pathogens may be assumed to be limited to the hours of darkness."¹²

Some potential biological agents are hardier than others. Certain bacteria enhance their chances of surviving harsh environments by turning into inactive spores. Anthrax spores are extremely difficult to destroy, and are known to survive in the soil for decades. Once exposed to a fertile environment, the bacteria return to an active and potentially virulent form. In the case of anthrax spores, the rate of decay is only about 0.1 percent per minute, and as a result spores released in an aerosol can survive for several days. Sunlight, however, will kill anthrax spores after a few hours.¹³ In addition, organisms can lose virulence after dissemination. As a result, even if the agent survives, the danger it poses may be reduced significantly.

¹⁰Gochenour, "Aerobiology," *Military Medicine*, pp. 87-88.

¹¹WHO, *Health Aspects of Chemical and Biological Weapons*, p. 94. The atmosphere lacks the nutrients required for growth, so that biological agents cannot reproduce in the air.

¹²Gochenour, "Aerobiology," *Military Medicine*, p. 88.

¹³WHO, *Health Aspects of Chemical and Biological Weapons*, p. 94, and Rothschild, *Tomorrow's Weapons*, p. 207.

“WEAPONIZATION” OF BIOLOGICAL AGENTS

Only small amounts of biological agents are required to produce significant strategic effects. Only about 200 kg (440 pounds) of tularemia, if spread in an optimal aerosol cloud, would be needed to infect an area of 100 km² (60 square miles). However, agent constitutes only a small part of the total weight of a biological munition. According to one estimate, a sophisticated munition intended to disseminate agent on the ground could weigh 40 times as much as the agent. Thus, dissemination of 50 kg (110 pounds) of agent could require a weapon weighing 2,000 kg (4,400) pounds. Another source estimates that dissemination of 200 kg (440 pounds) of tularemia requires munitions that weigh 5,000 kg (11,000 pounds), apparently relying on a simpler airborne spray system.¹⁴ Given that 50 kg (110 pounds) of a biological agent is a militarily significant amount, the weight constraints do not appear to be excessive.

Since the late 1930s, efforts have been made to design munitions capable of disseminating biological agents. Some of the earliest such weapons were based on designs originally created for chemical agents. Such munitions contained several pounds of liquid containing a biological agent, usually anthrax, and a high explosive burster charge. Detonation of the explosive sprayed the liquid in large drops in all directions.

The drops produced by this process were considerably larger than the optimal size for biological agents. Accordingly, the focus of biological weapons research has concentrated on the design of munitions capable of generating aerosols consisting of small particles of biological agent. Delivery systems for biological weapons came to include “missile warheads, spray-tanks mounted on manned or unmanned aircraft, and aerial bombs, cluster bomblets, or bomblet dispensers.”¹⁵ It appears that the United States standardized three basic types of dissemination systems for aerosols:

¹⁴The first figure is from WHO, *Health Aspects of Chemical and Biological Weapons*, pp. 94-95. The second estimate was derived from the first, and comes from Meselson, Kaplan, and Mokulsky, “Verification of Biological and Toxin Weapons Disarmament,” p. 152.

¹⁵World Health Organization, *Health Aspects of Chemical and Biological Weapons* (Geneva: World Health Organization, 1970), p. 84.

- (1) Cluster bomblets carried by aircraft and missiles;
- (2) Flettner-rotor munitions carried by aircraft and missiles;
- (3) Spray-tanks carried by aircraft and unmanned drones.

Both the bomblets and Flettner-rotor munitions were designed to disseminate agent at ground level. The bomblets were small munitions filled with liquid agent designed to detonate upon impact with the ground. Two or three bomblets were sufficient to cover a square mile. Although Flettner-rotor munitions were developed in the late 1950s, the designs remain classified. It appears, however, that they were small devices consisting of a tank of biological agent and a small device that sprayed the contents of the tank into the air. It appears that alternative delivery mechanisms were explored as well, including use of fuel air explosives.¹⁶

ASSESSMENT

Clearly, disseminating biological agents is not an easy process, requiring highly sophisticated capabilities in both the handling of agent and in the design of ordnance. Effective military employment of biological weapons will require considerable investment and involve the services of highly trained scientists and engineers. This supports the conclusion reached by the experts consulted by the World Health Organization.

Although biological agents themselves are easy to produce, complex production and delivery systems are needed if even minimal reliance is to be placed on the outcome of an attack, except perhaps where the intention is simply to produce social disruption by a limited sabotage effort (e.g., the introduction of smallpox).¹⁷

¹⁶For a discussion of biological warfare munitions, see SIPRI, *The Problem of Chemical and Biological Warfare*, Volume II, pp. 72-81.

¹⁷WHO, *Health Aspects of Chemical and Biological Weapons*, p. 18.

Despite the difficulties, it appears possible to disseminate biological agents, and it appears that they can be employed militarily with potentially great effect.

APPENDIX III DEFENDING AGAINST BIOLOGICAL AGENTS

Protection of military forces from biological agents involves five types of defenses:

- (1) [pre-exposure] immunization;
- (2) systems to detect biological agents;
- (3) gas masks;
- (4) [post-exposure] medical treatment;
- (5) decontamination.¹

The United States and other countries have attempted to provide their military forces and civilian populations with some of these protections.²

Vaccines have been developed against many potential biological agents, including anthrax. The anthrax vaccine is made of dead anthrax bacteria, and must be injected in three separate doses (two booster shots must be provided at two week

¹Charles R. Phillips and Benjamin Warshowsky, "Physical Defense Against Biological Operations," *Military Medicine*, February 1963, p. 110.

²Carl-Gorgen Heden, "Defenses Against Biological Warfare," *Annual Review of Microbiology*, 1967, pp. 639-676. This article provides a comprehensive survey of issues related to biological defenses. I am indebted to Raymond Zilinskas for providing me with a copy of this article.

intervals after the initial injection).³ Unfortunately, vaccines provide an uncertain barrier against biological agents. It is impossible to inoculate people against more than a few of the many organisms that could be used as biological agents. Moreover, vaccines may not provide adequate protection against heavy concentrations of aerosolized biological agent.⁴

Gas masks provide an excellent defense against biological agents. Modern protective masks can remove 99.99 percent of particles between 1 and 5 microns in size. Even simple expedients can provide some protection. According to one study, a simple mask consisting of nothing more than three layers of toilet tissue can block 90 percent of the organisms.⁵ Unfortunately, masks are effective only if users are warned of a potential attack. Despite intensive efforts, it has not been possible to develop warning devices that can provide immediate warning of the presence of biological agents. As a result, the effectiveness of modern masks may be of limited practical benefit under many circumstances.

³Malcolm W. Browne, "Army reportedly Ready for Iraqi Germ Warfare," *The New York Times*, December 28, 1990, p. A6.

⁴Meselson, Kaplan, and Mokulsky, "Verification of Biological and Toxin Weapons Disarmament," in Francesco Calogero, Marvin L. Goldberger, and Sergei Kapitza, eds., *Verification—Monitoring Disarmament* (Boulder, Colorado: Westview, 1990), p. 153, discusses some of the problems of reliance on vaccines.

⁵Phillips and Warshowsky, "Physical Defense Against Biological Operations," pp. 113-114.

TABLE I
CHARACTERISTICS OF BIOLOGICAL AGENTS

Table I: Biological Agents
 Characteristics of Biological Agents

Agent	Type	Methods of Dissemination	Fatality Rate	Contagiousness	Organisms needed for infection	Remarks
Botulism	Toxin	aerosol, food, fomites*	60-70% (in the United States)	None	Not applicable	One of the most toxic substances known to man. Decomposes after 12 hours in the air.
Anthrax	Bacteria	aerosol, food, fomites	Inhalatory: 90-99% Skin: 5-20% Untreated: negligible with treatment	None	20,000 (inhalation)	Stable for years in storage. Will survive for hours in sunlight, extending to days if not exposed to the sun.
Brucellosis	Bacteria	aerosol, water, food, insects	Untreated: 2-5% Treated: less than 2%	None	1,300 (inhalation)	Stable for months in storage
Cholera	Bacteria	aerosol (?), water, food, insects	Untreated: up to 50% Treated: less than 1%	None	Unknown	

Q fever	Rickettsia	aerosol, water, fomites	Untreated: 1-4% Treated: less than 1%	Negligible	1	Stable for long periods in dry storage
Tularemia	Bacteria	aerosol, water, food, insects	Untreated: 5-8% Treated: less than 1%	None	10	Can be stored for long periods
Venezuelan Equine Encephalomyelitis (VEE)	Virus	aerosol, insects	Less than 1%	None	small	Decays rapidly
Yellow Fever	Virus	aerosol, insects	Less than 5%, but possibly over 50% if previously unexposed	None	one insect bite	

*Fomites are non-living material, such as dirty linen, which can transmit disease.

Sources: Abram S. Benenson, editor, *Control of Communicable Diseases*, 15th edition (Washington, D.C.: American Public Health Association, 1990); J.H. Rothschild, *Tomorrow's Weapons* (New York: McGraw Hill Book Company, 1964); World Health Organization, *Health Aspects of Chemical and Biological Weapons* (Geneva: World Health Organization, 1970); U.S. Army Chemical School, *Toxins*, FC 3-9-1, August 1988.

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