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DEFENDING AMERICA

ASYMMETRIC AND TERRORIST ATTACKS WITH BIOLOGICAL WEAPONS

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Types of Attack: Determining Future Methods of Attack and the Needed Response

The US must plan its Homeland defense policies and programs for a future in which there is no way to predict the weapon that will be used or the method chosen to deliver a weapon which can range from a small suicide attack by an American citizen to the covert delivery of a nuclear weapon by a foreign state. There is no reason the US should assume that some convenient Gaussian curve or standard deviation, will make small or medium level attacks a higher priority over time than more lethal forms.

The US government is still deciding how to come to grips with these problems and how to assess possible methods of attack. A GAO report that summarized CIA and FBI views on these issues reached the following conclusions, although it must be stressed that the analysis focused on the normal historical pattern of actions by terrorists/extremists, and largely excluded attacks by state actors, proxy attacks, or covert attacks:[1]

> The possibility that terrorists may use chemical or biological materials may increase over the next decade, according to intelligence agencies. According to the Central Intelligence Agency (CIA), interest among non- state actors, including terrorists, in biological and chemical materials is real and growing and the number of potential perpetrators is increasing. The CIA also noted that many such groups have international networks and do not need to be tied to state sponsors for financial and technical support. Nonetheless, the CIA continues to believe that terrorists are less likely to use chemical and biological weapons than conventional explosives. We previously reported that according to intelligence agencies, terrorists are less likely to use chemical and biological weapons than conventional explosives, at least partly because chemical and biological agents are difficult to weaponize and the results are unpredictable.
>
> …The CIA classified the specific agents identified in intelligence assessments that would more likely be used by foreign- origin terrorists. The CIA also classified the intelligence judgments about the chances that state actors with successful chemical and/ or biological warfare programs would share their weapons and materials with terrorists or terrorist groups. Unlike the foreign- origin threat, the FBI's analysts' judgments concerning the more likely chemical and biological agents that may be used by domestic- origin terrorists have not been captured in a formal assessment. However, FBI officials shared their analyses of the more likely biological and chemical threat agents on the basis of substances used or threatened in actual cases.
>
> In analyzing domestic-origin threats, FBI officials grouped chemical and biological agents and did not specify individual agents as threats. Although the FBI has not addressed the specific types of chemical or biological weapons that may be used by domestic terrorists in the next 2 to 5 years, FBI officials believe that domestic terrorists would be more likely to use or threaten to use biological agents than chemical agents.
>
> The FBI's observation is based on an increase in reported investigations involving the use of biological materials. In 1997, of the 74 criminal investigations related to weapons of mass destruction, 30 percent (22)

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were related to the use of biological materials. In 1998, there were 181 criminal investigations related to weapons of mass destruction, and 62 percent (112) were related to the use of biological materials. Most of these investigations involved threats or hoaxes. The FBI estimated that in 1997 and 1998, approximately 60 percent of biological investigations were related to anthrax hoaxes.

The FBI ranks groups of chemical and biological agents on its threat spectrum according to the likelihood that they would be used.

- Biological toxins: any toxic substance of natural origin produced by an animal or plant. An example of a toxin is ricin, a poisonous protein extracted from the castor bean.
- Toxic industrial chemicals: chemicals developed or manufactured for use in industrial operations such as manufacturing solvents, pesticides, and dyes. These chemicals are not primarily manufactured for the purpose of producing human casualties. Chlorine, phosgene, and hydrogen cyanide are industrial chemicals that have also been used as chemical warfare agents.
- Biological pathogens: any organism (usually living) such as a bacteria or virus capable of causing serious disease or death. Anthrax is an example of a bacterial pathogen.
- Chemical agents: a chemical substance that is intended for use in military operations to kill, seriously injure, or incapacitate people. The FBI excludes from consideration riot control agents and smoke and flame materials. Two examples of chemical agents are Sarin (nerve agent) and mustard gas (blister agent).

The First Annual Report of the Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving the Use of Weapons of Mass Destruction took a somewhat different path. It downplayed the CBRN threat largely because of the current technical problems non-state actors confront in using weapons of mass destruction,[2]

> Many government officials and concerned citizens believe that it is not a question of if, but when, an incident will occur that involves the use by a terrorist of a chemical, biological, radiological, and nuclear (CBRN) weapon – a so-called 'weapon of mass destruction' (WMD – that is designed, intended or has the capability to cause 'mass destruction' or 'mass casualties.' In recent years, some has depicted terrorist incidents as causing catastrophic loss of life and extensive structural and environmental damage as not only possible but probable. Such depictions do not accurately portray the full range of terrorist threats...While such a devastating event is within the realm of possibility…
>
> In our opinion, some fundamental questions should be answered before the federal government builds and expands programs, plans, and strategies to deal with the threat of WMD terrorism: How easy or difficult is it for terrorists (rather than state actors) to successfully use chemical or biological WMDs in an attack causing mass casualties? And if it is easy to produce and disperse chemical and biological agents, why have there been no WMD terrorist attacks before or since the Tokyo subway incident? What chemical and biological agents does the government really need to be concerned about? We have not yet seen a thorough assessment or analysis of these questions. It seems to us that, without such an assessment or analysis and consensus in the policy-making community, it would be very difficult—maybe impossible—to properly shape programs and focus resources.
>
> Statements in testimony before the Congress and in the open press by intelligence and scientific community officials on the issue of making and delivering a terrorist WMD sometimes contrast sharply. On the one hand, some statements suggest that developing a WMD can be relatively easy. For example, in 1996, the Central Intelligence Agency Director testified that chemical and biological weapons can be produced with

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relative ease in simple laboratories, and in 1997, the Central Intelligence Agency Director said that "delivery and dispersal techniques also are effective and relatively easy to develop." One article by former senior intelligence and defense officials noted that chemical and biological agents can be produced by graduate students or laboratory technicians and that general recipes are readily available on the internet.

On the other hand, some statements suggest that there are considerable difficulties associated with successfully developing and delivering a WMD. For example, the Deputy Commander of the Army's Medical Research and Materiel Command testified in 1998 about the difficulties of using WMDs, noting that "an effective, mass-casualty producing attack on our citizens would require either a fairly large, very technically competent, well-funded terrorist program or state sponsorship." Moreover, in 1996, the Director of the Defense Intelligence Agency testified that the agency had no conclusive information that any of the terrorist organizations it monitors were developing chemical, biological, or radiological weapons and that there was no conclusive information that any state sponsor had the intention to provide these weapons to terrorists. In 1997, the Central Intelligence Agency Director testified that while advanced and exotic weapons are increasingly available, their employment is likely to remain minimal, as terrorist groups concentrate on peripheral technologies such as sophisticated conventional weapons.

Illustrative Attack Scenarios

The federal, state, and local governments are almost certainly correct in assuming that the *current* threat of conventional attack is notably higher than the risk of CBRN attack, and that the use of relatively low levels of CBRN attack is currently higher than the risk of high levels of CBRN attack. The analysis of the nature and lethality of the threat changes considerably, however, if states conduct covert CBRN attacks, or give them to proxies or independent movements. It also changes over time as technology makes the use of biological weapons more available, and as the time horizon for estimating the risk of some form of high level CBRN attack is extended to the quarter of the country that US planners must consider in shaping long-term programs and RDT&E activities

Under these conditions, there are many scenarios where different types of CBRN weapons could have lethalities and costs up to several orders of magnitude higher than those that occurred as a result of the World Trade Center, Oklahoma City, and Aum Shinrikyo attacks. Consider the following scenarios:

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- A radiological powder is introduced into the air conditioning systems of several high-rise office buildings, hostels, etc, possibly in several cities over a matter of weeks. Symptoms are only detected over days or weeks and public warning is given several weeks later. The authorities now detect the presence of such a powder, but cannot estimate its long-term lethality and have no precedents for decontamination. Local tourism collapses, no one will enter the building area, and the buildings eventually have to be torn down and rebuilt.

- A Country X or a Country X-backed terrorist group smuggles in parts for a crude gun-type nuclear device. The device is built in a medium sized commercial truck. The group uses a US Department of Defense weapons effects manual, maps a US city to maximize fallout effects in an area filled with buildings with heavy metals, and waits for a wind maximizing the fallout impact. The group also searches the US literature response measures to pick wind patterns that complicate the response effort and affect a maximum number of first responders. The bomb explodes with a yield of only a few kilotons, but with high levels of radiation. Immediate casualties are serious and the long-term death rate mounts steadily with time.

- Several workers move drums labeled as cleaning agents into a large shopping mall, large public facility, subway, train station, or airport. They dress as cleaners and are wearing what appear to be commercial dust filters or have taken the antidote for the agent they will use. They mix the feedstocks for a persistent chemical agent at the site during a peak traffic period.

- Immunized terrorists carry Anthrax powder into a building or urban area in containers designed to make them look like shopping bags, brief cases, suitcases, etc. They pick sites where their study of federal, state, and local governments indicate that detection is unlikely, and local response capabilities are limited. They slowly scatter the powder as they walk through the areas. The US does not detect the attacks until days or weeks after they occur. It then finds it has no experience with decontaminating a number of large buildings or areas where Anthrax has entered the air system and is scattered throughout closed areas. After long debates over methods and safety levels, the facilities and areas are temporarily abandoned. (A variation on this scenario is the use of a form of inhaled Anthrax modified to prevent effective immunization and use of normal medical treatment.

- A Country X or a Country X-backed terrorist group seeking to “cleanse” the US introduces a modified type culture of Ebola or a similar virus into urban areas. It scatters infectious cultures for which there is no effective immunization and only limited treatment, capitalizing on years of strategic warning regarding what vaccines the US is developing and stockpiling, and the open literature on the limits to US detection and response capabilities. By the time the attack(s) are detected, they have reached epidemic proportions, causing the collapse of medical facilities and emergency response capabilities. Other nations and regions have no alternative other than to isolate the part of the US under attack, letting the disease take its course.

- A Country X or a Country X-backed terrorist group modifies the valves on a Japanese remote-controlled crop spraying helicopter that has been imported legally for agricultural purposes. It uses this system at night or near dawn to spray a chemical or biological agent at altitudes below radar coverage in a line-source configuration. Alternatively, it uses a large home-built RPV with simple GPS guidance. The device eventually crashes undetected into the sea or in the desert. Delivery of a chemical agent achieves far higher casualties than a conventional military warhead. A biological agent would be equally effective and the first symptoms might appear days after the actual attack – by which time the cause would be impossible to determine and treatment could be difficult or impossible.

- A truck filled with what appears to be light gravel is driven through the streets of a city during rush hour or another heavy traffic period. A visible powder does come out through the tarpaulin covering the truck, but the spread of the power is so light that no attention is paid to it. The driver and his assistant are

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immunized against the modified form of Anthrax carried in the truck, which is being released from behind the gravel or sand in the truck. The truck slowly quarters key areas of the city. Unsuspected passersby and commuters not only are infected, but carry dry spores home and into other areas. By the time the first major symptoms of the attack occur some 3-5 days later, Anthrax pneumonia is epidemic and some septicemic Anthrax has appeared. Some 40-65% of the exposed population dies and medical facilities collapse causing serious, lingering secondary effects.

- A Country X or a Country X-backed terrorist group scatters high concentrations of a radiological, chemical, or biological agent in various areas in a city, and trace elements into the processing intakes to the local water supply. When the symptoms appear, the terrorist group makes its attack known, but claims that it has contaminated the local water supply. The authorities are forced to confirm that water is contaminated and mass panic ensues.

- Immunized terrorists carry small amounts of Anthrax or a similar biological agent onto a passenger aircraft like a B-747, quietly scatter the powder, and deplane at a regular scheduled stop. No airport detection system or search detects the agent on the plane. Some 70-80% of those who fly on the aircraft die as a result of symptoms that only appear days later. It takes weeks to detect the fact that the aircraft remains contaminated.

- Several identical nuclear devices are smuggled out of the FSU. One of the devices is disassembled to determine the precise technology and coding system used in the weapon's PAL. This allows users to activate the remaining weapons. The weapon is then disassembled to minimize detection with the fissile core shipped covered in lead. The weapon is successfully smuggled into the periphery of an urban area outside any formal security perimeter. A 10+ kiloton ground burst destroys a critical area and blankets the region in fallout.

- The same device is shipped to a US port area in a modified standard shipping container equipped with considerable shielding and detection and triggering devices that set it off either when the container is opened at any point near or in the US or using information from a GPS system that sets it off automatically when it reaches the proper coordinates. The direct explosive effect is significant, and even if it detonates at Customs, the damage and "rain out" contaminate a massive local area.

- A Country X or a Country X-backed develops a radiation fallout model using local weather data that it confirms by sending out scouts with simple commercial wind measurement equipment and cellular phones. It waits for the ideal wind pattern and detonates a nuclear device for maximum contamination of a city or critical economic areas. Alternatively, the same group uses a similar weather model, waits for the proper wind pattern and allows the wind to carry a biological agent over a city.

- Simultaneous release takes place of Anthrax spores at 10-20 scattered subway platforms during rush hour, and at commuter rail stations as well. No notice is given of the attack. Incubation takes 1-7 days, and the attack is only detected when massive numbers of cases in the acute phase exhibit flu-like symptoms and then enter the breathing difficulty and shock phase (1-2 days after incubation.) Several million commuters are potential exposed, but the locations of the attack are unknown, and effective triage is now impossible. Prompt treatment is no longer possible. Local and regional medical facilities collapse.

- An illegal smallpox culture is used or stolen. The agent is planted in the air duct of aircraft flying to an airport in the target country. The first cases occur two weeks after the flight(s). Widespread infection presents major problems because of a lack of the ability to trace passengers and secondary infections. Mass panic affects national medical facilities and some 10-30% of those infected die.

- A freighter carrying fertilizer enters a port and docks. In fact, the freighter has mixed the fertilizer with a

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catalyst to create a massive explosion that also disseminates a large amount of a radiological, and/or biological agent. Response focuses on the damage done by the resulting explosion. The scattering of a radiological or biological weapon over the area is only detected days later.

- A large terrorist device goes off in a populated, critical economic, or military assembly area – scattering mustard or nerve gas. Emergency teams react quickly and deal with the chemical threat and the residents are evacuated. Only later does it become clear that the device also included a biological agent and that the response to this "cocktail" killed most emergency response personnel and the evacuation rushed the biological agent to a much wider area.

- Country X or a proxy group attacks US agriculture with a foreign pest or disease that could be transmitted by normal commerce and which is genetically enhanced. The US suffers major economic damage and never knows it is under attack. Alternatively, it uses a mix of normal plant diseases plus an add on weaponized agent. The US fails to react to the added agent until it discovered the true scale of the problem weeks later, it then finds it has only limited near to mid-term countermeasures. It never conclusively identifies its attacker.

- Country X, a terrorist or proxy group attacks the US with a biological agent in very small amounts in many areas in the US. The US is forced to mount a massive nation-wide preemptive effort at vast expense, even though it is only under limited attack. The attack is tailored to counter the highly detailed open literature on US federal, state, and local detection and response capabilities.

- A local terrorist group produces Ricin from castor beans and either distributes the toxin through the air intake of a government building or sprays it from a truck moving down a street. The first symptoms do not appear until three hours later and there is no know treatment. Significant deaths occur within 36-72 hours.

This list of possible attack scenarios illustrates the fact that a wide range of highly lethal CBRN attacks are practical, although most would *now* require an attacker to at least have access to the level of technology available only to governments. Second, it shows how dangerous it is to assume that attacks have to follow any rules or be carried out in a predictable way. Third, it shows that many attacks can defeat "first response" as well as avoid early US efforts at detection or containment, and/or can be tailored to bypass or counter many of the measures the US is currently exploring for Homeland defense. Fourth, it illustrates the fact that attackers can use more than one means of attack at the same time. Finally, it illustrates the dangers of leaving any gap in Homeland defense between responding to overt warfare like missile attacks and to relatively limited attacks by terrorists.

"Conventional" Means of Attack

The previous scenarios do not mean that attacks using conventional explosives are not

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lethal, or more probable than CBRN attacks. Most terrorist/extremist attacks to date on Americans inside and outside the US have used conventional explosives, and the World Trade Center and Oklahoma City bombings show that such attacks can be very costly. There are also good reasons why some federal agencies see the large-scale use of conventional explosives as a "weapon on mass destruction."

The US Department of Defense has carried out many vulnerability analyses over the years that have highlighted critical targets for conventional attack ranging from communications grids to political leadership. Some of these studies focused on the risk of using high explosive attacks by Soviet Spetznaz during the Cold War, and exposed the vulnerability of key plants and military facilities in the US. US utility companies have carried out vulnerability studies and have found other important "weak links" in the US infrastructure. They have found that conventional attacks could be far more lethal if the attacker had the expertise to target vulnerabilities and place explosives more precisely than terrorists have done in the past.

There is also no reason that attackers cannot combine conventional explosives with the use of weapons of mass destruction. Sophisticated attackers might well find that a mix of different forms of attacks would do most to increase damage or political effect. One such scenario might be mixing a conventional bomb with a chemical or biological weapon, with the idea that the rush of response teams into the bombed area would greatly increase the number of casualties.

As a result, it is clear that the US needs to continue to improve many of its capabilities to detect conventional forms of attack, improve its regular counterterrorism and law enforcement activity, improve its defenses, and consider finding ways of reducing conventional vulnerability as well as deal with CBRN attacks. What is not clear, however, is how much of this effort should be part of new Homeland Defense activities as distinguished from part of the normal ongoing effort to improve counterterrorism, security procedures, and the effort to secure airports, major government facilities, utilities, etc. It may be best for Homeland Defense to concentrate on what should or should not be done to deal with the unique threat posed by weapons of mass

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destruction, knowing that such improvements will have an impact in improving US capabilities to deal with lesser threats and leaving the primary focus of such "defense" activity up to the Department of Justice, FBI, FEMA, and state and local authorities.

The previous historical analyses of patterns of attack does not indicate that conventional explosives and weapons now pose the kind of major threat to the US that requires a major response beyond existing counter-terrorism, law enforcement, and emergency response capabilities. It is also important to note in this regard that risk, casualties and damage are an actual fact of life. The US homeland is under almost constant attack by a terrorist called "Mother Nature," and that accidents pose at least as much of a historical threat as conventional terrorism.

Weapons of Mass Destruction

The previous scenarios do indicate, however, that the US must fully recognize the risk posed by chemical, biological, nuclear, and radiological weapons differ sharply in character and in their effects. Each form of weapon can be used in ways that present radically different problems for defense and response. The key differences in the character and use each type of weapon are summarized in Table 4.1, and it is clear that each can have very different impacts, regardless of whether it is used against military or civilian targets.

The broad differences in the lethality of each type of weapon are equally important, and are shown in Table 4.2. It should be noted, however, that much depends on the size of the weapon and the way in which it is employed. The actual design of a given weapon or device is almost totally unpredictable but will be critical in determining its actual lethality. Once again, there also are no clear precedents or paradigms that can be used for planning Homeland defense.

These problems are compound by the fact that theoretical lethality models are filled with gross uncertainties, and there is little chance that any current database, model, or simulation can be used to accurately predict the actual consequences of the use of such weapons. The data in Tables Five and Six are typical of such modes and they are derived from models whose primary

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purpose was to examine what state actors could do using bombs and missiles in warfare. They were not intended to reflect the character and lethality of the chemical, biological, nuclear, and radiological weapons in the kind of smaller attacks that might take place under covert conditions, or by proxies, terrorists, and extremists. There is also good historical reason to question whether chemical weapons are normally as lethal as Tables 4.1 and 4.2 imply. They fail to distinguish between methods of delivery of biological weapons and tacitly assume the optimal use of dry micropowders when actual attacks may use much cruder "wet" weapons with limited or no lethality.

There also is no reason to assume that effects should be measured in terms of casualties or physical damage attacks using "weapons of mass destruction" do not have to be used to cause mass destruction. With the exception of nuclear weapons, they can be used in virtually any size, and attackers can exploit their different effects to attack very small targets and highly localized areas as well as cities and large populated areas. Even nuclear weapons are available in fractions of a kiloton, and chemical, biological, and radiological weapons can be used for the purposes of assassination or attacking individual buildings.

Attackers will generally have a political or ideological motive. The psychological and political aspects of using weapons of mass destruction cannot be quantified in any form but can be exploited in ways where the number of casualties, and the amount of physical damage, may be far less important than the impact on public opinion, crowd behavior, and the political perceptions of foreign states. The very threat of such attacks can cause panic, and the risk of contamination can deny the use of a facility even if contamination is minimal or no longer exists. At the same time, a successful biological or nuclear attack on US territory might radically change world perceptions of American strength and vulnerability, even if the target was poorly chosen and casualties were limited.

This latter point is ignored in some studies. The fact that an attacker would be perceived in radically different terms if it successfully used a weapon of mass destruction against the US is viewed only as a deterrent to using such weapons. In fact, it is a two-edged sword. There is no

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other way many attackers could change perceptions of their importance so quickly. Aum Shinrikyo is not memorable for the casualties it caused, but rather because it used chemical weapons and prepared biological weapons. Missiles were Iraq's only memorable response during the Gulf War.

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Table 4.1

Key Characteristics of Weapons of Mass Destruction -Part One

Chemical Weapons:

Destructive Effects: Poisoning skin, lungs, nervous system, or blood. Contaminating areas, equipment, and protective gear for periods of hours to days. Forcing military units to don highly restrictive protection gear or use incapacitating antidotes. False alarms and panic. Misidentification of the agent, or confusion of chemical with biological agents (which may be mixed) leading to failure of defense measures. Military and popular panic and terror effects. Major medical burdens that may lead to mistreatment. Pressure to deploy high cost air and missile defenses. Paralysis or disruption of civil life and economic activity in threatened or attacked areas.

Typical Targets: Infantry concentrations, air bases, ships, ports, staging areas, command centers, munitions depots, cities, key oil and electrical facilities, desalinization plants.

Typical Missions: Killing military and civilian populations. Intimidation. Attack of civilian population or targets. Disruption of military operations by requiring protective measures or decontamination. Area or facility denial. Psychological warfare, production of panic, and terror.

Limitations: Large amounts of agents are required to achieve high lethality, and military and economic effects are not sufficiently greater than careful target conventional strikes to offer major war fighting advantages. Most agents degrade quickly, and their effect is highly dependent on temperature and weather conditions, height of dissemination, terrain, and the character of built-up areas. Warning devices far more accurate and sensitive than for biological agents. Protective gear and equipment can greatly reduce effects, and sufficiently high numbers of rounds, sorties, and missiles are needed to ease the task of defense. Leave buildings and equipment reusable by the enemy, although persistent agents may require decontamination. Persistent agents may contaminate the ground the attacker wants to cross or occupy and force use of protective measures or decontamination.

Biological Weapons

Destructive Effects: Infectious disease or biochemical poisoning. Contaminating areas, equipment, and protective gear for periods of hours to weeks. Delayed effects and tailoring to produce incapacitation or killing, treatable or non-treatable agents, and be infectious on contact only or transmittable. Forcing military units to done highly restrictive protection gear or use incapacitating vaccines antidotes. False alarms and panic. High risk of at least initial misidentification of the agent, or confusion of chemical with biological agents (which may be mixed) leading to failure of defense measures. Military and popular panic and terror effects. Major medical burdens that may lead to mistreatment. Pressure to deploy high cost air and missile defenses. Paralysis or disruption of civil life and economic activity in threatened or attacked areas.

Typical Targets: Infantry concentrations, air bases, ships, ports, staging areas, command centers, munitions depots, cities, key oil and electrical facilities, desalinization plants. Potentially fare more effective against military and civil area targets than chemical weapons.

Typical Missions: Killing and incapacitation of military and civilian populations. Intimidation. Attack of civilian population or targets. Disruption of military operations by requiring protective measures or decontamination. Area or facility denial. Psychological warfare, production of panic, and terror.

Limitations: Most wet agents degrade quickly, although spores, dry encapsulated agents, and some toxins are persistent. Effects usually take some time to develop (although not in the case of some toxins). Effects are unpredictable, and are even more dependent than chemical weapons on temperature and weather conditions, height of dissemination, terrain, and the character of built-up areas. Major risk of

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contaminating the wrong area. Warning devices uncertain and may misidentify the agent. Protective gear and equipment can reduce effects. Leave buildings and equipment reusable by the enemy, although persistent agents may require decontamination. Persistent agents may contaminate the ground the attacker wants to cross or occupy and force use of protective measures or decontamination. More likely than chemical agents to cross the threshold where nuclear retaliation seems justified.

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Table 4.1

Key Characteristics of Weapons of Mass Destruction -Part Two

Nuclear Weapons

Destructive Effects:	Blast, fire, and radiation. Destruction of large areas and production of fallout and contamination -- depending on character of weapon and height of burst. Contaminating areas, equipment, and protective gear for periods of hours to days. Forcing military units to **don** highly restrictive protection gear and use massive amounts of decontamination gear. Military and popular panic and terror effects. Massive medical burdens. Pressure to deploy high cost air and missile defenses. Paralysis or disruption of civil life and economic activity in threatened or attacked areas. High long term death rates from radiation. Forced dispersal of military forces and evacuation of civilians. Destruction of military and economic centers, and national political leadership and command authority, potentially altering character of attacked nation and creating major recovery problems.
Typical Targets:	Hardened targets, enemy facilities and weapons of mass destruction, enemy economic, political leadership, and national command authority. Infantry and armored concentrations, air bases, ships, ports, staging areas, command centers, munitions depots, cities, key oil and electrical facilities, desalinization plants.
Typical Missions:	Forced dispersal of military forces and evacuation of civilians. Destruction of military and economic centers, and national political leadership and command authority, potentially altering character of attacked nation and creating major recovery problems.
Limitations:	High cost. Difficulty of acquiring more than a few weapons. Risk of accidents or failures that hit friendly territory. Crosses threshold to level where nuclear retaliation is likely. Destruction or contamination of territory and facilities attacker wants to cross or occupy. High risk of massive collateral damage to civilians if this is important to attacker.

Source: Adapted by the Anthony H. Cordesman from Office of Technology Assessment, Proliferation of Weapons of Mass Destruction: Assessing the Risks, US Congress OTA-ISC-559, Washington, August, 1993, pp. 56-57.

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Table 4.2

The Comparative Effects of Biological, Chemical, and Nuclear Weapons Delivered Against a Typical Urban Target

Using missile warheads: Assumes one Scud-sized warhead with a maximum payload of 1,000 kilograms. The study assumes that the biological agent would not make maximum use of this payload capability because this is inefficient. It is unclear this is realistic.

	Area Covered in Square Kilometers	Deaths Assuming 3,000-10,000 people Per Square Kilometer
Chemical: 300 kilograms of Sarin nerve gas with a density of 70 milligrams per cubic meter	0.22	60-200
Biological 30 kilograms of Anthrax spores with a density of 0.1 milligram per cubic meter	10	30,000-100,000
Nuclear:		
One 12.5 kiloton nuclear device achieving 5 pounds per cubic inch of over-pressure	7.8	23,000-80,000
One 1 megaton hydrogen bomb	190	570,000-1,900,000

Using one aircraft delivering 1,000 kilograms of Sarin nerve gas or 100 kilograms of Anthrax spores: Assumes the aircraft flies in a straight line over the target at optimal altitude and dispensing the agent as an aerosol. The study assumes that the biological agent would not make maximum use of this payload capability because this is inefficient. It is unclear this is realistic.

	Area Covered in Square Kilometers	Deaths Assuming 3,000-10,000 people Per Square Kilometer
Clear sunny day, light breeze		
Sarin Nerve Gas	0.74	300-700
Anthrax Spores	46	130,000-460,000
Overcast day or night, moderate wind		
Sarin Nerve Gas	0.8	400-800
Anthrax Spores	140	420,000-1,400,000
Clear calm night		
Sarin Nerve Gas	7.8	3,000-8,000
Anthrax Spores	300	1,000,000-3,000,000

Source: Adapted by the Anthony H. Cordesman from Office of Technology Assessment, Proliferation of Weapons of Mass Destruction: Assessing the Risks, US Congress OTA-ISC-559, Washington, August, 1993, pp. 53-54.

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Biological Weapons as Means of Attack

One way of describing the risks posed by biological weapons is to describe the world that existed when natural outbreaks of disease were a recurrent fact of life. A recent WHO study provides a good overview of the impact of disease on history,[3]

> It is arguable whether war or the devastation wrought by infectious disease has had a greater historic influence on political boundaries. Up until the Second World War, it was pestilence – and not warfare – that claimed the lives of Europe's soldiers. Napoleon Bonaparte can lay blame for his ignominious retreat from Moscow – not on the Russians, nor even the Russian winter. By far, his deadliest opponent was typhus; a louse-borne infection that reduced a healthy Grande Armee of 655 000 to a pitiful and demoralized 93 000 – who wound up straggling home and surviving just long enough to pass the rickettsia on to neighbours and loved ones. The subsequent epidemic killed another two million, carrying off 250 000 civilians in Germany alone.
>
> In the New World, it was not superior Spanish firepower, nor their reliance on horses that resulted in the conquest and enslavement of the Amerindians. By far the greatest allies of the self-proclaimed, "liberators of the heathens" were smallpox, influenza and measles. Formerly unknown in the Americas, the first recorded smallpox epidemic hit the fledgling colony of Santo Domingo in 1495, destroying 80% of the local indigenous population. That same outbreak was also responsible for the deaths of hundreds of Spanish soldiers after the battle of Vega Real in 1495.
>
> In 1515, another flare-up in Puerto Rico spared the Spanish but extirpated the locals. By the time Hernando Cortes and his rogue's army of mercenaries and missionaries set foot on Mexico's shores, smallpox, measles and influenza had already insinuated themselves as a kind of microbial fifth column among the local population. How a ragtag army of 300 men (albeit armed with muskets, riding horses and unbridled greed) could defeat the highly organized and warlike Aztecs can never be satisfactorily explained except by factoring in the inroads European diseases made into a people entirely devoid of immunity. Conquistador and expedition scribe Bernal Diaz described the resultant carnage from infectious disease thus: "We could not walk without treading on the bodies and heads of dead Indians. The dry land was piled with corpses." In the space of 10 years, historians estimate that Mexico's population plummeted from some 25 million to 6.5 million owing to epidemics of infectious disease – a drop of 74%. In North America, later events echoed those in Mexico but with one not-so-subtle difference. By the 1600s, colonizers knew enough about epidemiology to maliciously inflict deadly diseases on locals by providing "gifts" of blankets and clothing infested with smallpox and typhus-bearing lice – the first recorded acts of biological warfare.

Biological weapons have never been used successfully in large-scale combat, or in effective covert and terrorist attacks. Japan was the only nation in World War II that made confirmed use of biological weapons, and it used relatively crude means. While Japan used biological weapons against some 12 Chinese cites, the total number of deaths does not seem to have exceed 10,000 – many of which were caused under controlled conditions by experiments using human beings as live subjects.[4] Other nations confined their efforts to experimentation or

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to developing such weapons for retaliatory purposes. For example, Britain produced over five million seed cakes of animal Anthrax to be dropped by bombers during World War II.

The past, however, is unlikely to be a representative prologue of the future. As Table 4.5 shows, a wide range of powers developed far effective biological weapons after World War II, and the development of biological weapons in the form of dry, storable micropowders dates back to the 1950s. Furthermore, Table 4.6 shows that the US lists a number of countries where biological weapons efforts are continuing, and US intelligence experts indicate that a classified list would be over twice as long.

As has been touched upon earlier, the technology necessary to produce biological weapons is proliferating as part of the broad transfer of biotechnology throughout the world. Many, if not most of the key technologies involved are now commercialized for food processing and pharmaceutical purposes. Modern biological weapons have become far more lethal and easy to deliver since World War II and have been stockpiled. For example US had stockpiles of seven weapons in 1969, at the time it renounced the use of biological weapons, and then was testing advanced biological warheads for the Polaris and Snark cruise missile.[5] Russia, France, Britain, China, North Korea, also had extensive stocks of such weapons in 1972, when the Biological Weapons Convention (BWC) was opened for signature. In spite of the fact that some 140 nations have now signed or ratified the BWC, US intelligence exports estimate that at least as 15 countries still stockpile such weapons.

Categorizing the Biological Threat

Modern biological weapons offer many potential advantages. They employ living agents or toxins produced by natural or synthetic agents to kill or injure humans, domestic animals, and crops. As Table 4.7 shows, there are a wide range of agents with many different and effects and they offer a wide range of ways to attack American citizens, crops, and live stock. They also are nearly ideal terror weapons with massive psychological as well as physiological consequences.

Such weapons fall into five main medical categories: Bacterial agents (Anthrax, plague,

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brucellosis, typhoid fever); rickettsial agents (typhus, Rocky Mountain spotted fever, Q-fever); viral agents (smallpox, influenza, yellow fever, encephalitis, dengue fever, chikungunga, Rift Valley Fever, and hemorrhagic fevers like Ebola, Marburg and Lassa); toxins (botulinum, staphylococcus enterotoxin, shigella toxin, aflatoxin); and fungal (coccidiodomyocosis). There are other anti-plant and anti-animal weapons that are not used against humans.

This helps explain why the US Center for Disease Control (CDC) has concluded that **t**he U.S. public health system and primary health-care providers must be prepared to address varied biological agents, including pathogens that are rarely seen in the United States. It has stated that,[6]

> "High-priority agents include organisms that pose a risk to national security because they"
>
> - can be easily disseminated or transmitted person-to-person;
> - cause high mortality, with potential for major public health impact;
> - might cause public panic and social disruption; and
> - require special action for public health preparedness

There are many different ways to categorize biological weapons according to lethality. The CDC divides them into three main categories: Category A, Category B, and Category C. The Category A weapons are.high-priority agents include organisms that pose a risk to national security because they can be easily disseminated or transmitted person-to-person; cause high mortality, with potential for major public health impact; might cause public panic and social disruption; and require special action for public health preparedness. They include:

- variola major (smallpox);
- *Bacillus anthracis* (Anthrax);
- *Yersinia pestis* (plague);
- *Clostridium botulinum* toxin (botulism);
- *Francisella tularensis* (tularaemia);
- filoviruses,

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    - Ebola hemorrhagic fever,
    - Marburg hemorrhagic fever; and
- arenaviruses,
    - Lassa (Lassa fever),
    - Junin (Argentine hemorrhagic fever) and related viruses.

Category B agents include biological weapons that are moderately easy to disseminate; cause moderate morbidity and low mortality; and require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance. They include

- *Coxiella burnetti* (Q fever);
- *Brucella* species (brucellosis);
- *Burkholderia mallei* (glanders);
- alphaviruses,
    - Venezuelan encephalomyelitis,
    - eastern and western equine encephalomyelitis;
- ricin toxin from *Ricinus communis* (castor beans);
- epsilon toxin of *Clostridium perfringens*; and
- *Staphylococcus* enterotoxin B.

There is a subset of Category B agents that include pathogens that are food- or waterborne.

These pathogens include but are not limited to

- *Salmonella* species,
- *Shigella dysenteriae*,
- *Escherichia coli* O157:H7,
- *Vibrio cholerae*, and

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- *Cryptosporidium parvum*.

Category C agents have third priority and include emerging pathogens that could be engineered for mass dissemination in the future because of their availability; ease of production and dissemination; and potential for high morbidity and mortality and major health impact. The preparedness for Category C agents requires ongoing research to improve disease detection, diagnosis, treatment, and prevention.

They include

- Nipah virus,
- hantaviruses,
- tickborne hemorrhagic fever viruses,
- tickborne encephalitis viruses,
- yellow fever, and
- multidrug-resistant tuberculosis.

Many of these weapons offer a means of attack that is potentially cheap, lethal, and hard to detect. At the same time, much depends on how well they are weaponized, both in terms of the agent and the way in which it is delivered. For example, the same disease is generally far more lethal in the form of a dry micropowder than can be disseminated and inhaled over a wide area than as a wet agent. Explosive warheads may waste much of the agent while spraying it upwind in a line source delivery may be highly effective. Wind patterns, temperature, and the presence of ultraviolet light can affect both lethality and the life of the agent. As a result, the same amount of the same agent can be several orders of magnitude more lethal under optimal weaponization and delivery conditions and potentially highly lethal agents can have minimal effectiveness under the wrong weaponization and delivery conditions.

This helps explain why the lethality models involved in estimating the impact of biological weapons are far more uncertain than those associated with conventional explosives, chemical weapons, and the immediate effects of nuclear weapons.[7] There is also little historical

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experience to build upon. Up until 1945, the development of biological weapons had only limited success. In fact, a recent history of biological weapons has found that every major power in World War II failed to develop highly effective weapons while its scientists either lied about their success or exaggerated their potential success, and their intelligence experts grossly exaggerated the potential threat from other states.[8]

The CDC also warns that there is no way to know in advance which newly emergent pathogens might be employed by terrorists and that it is imperative to link "bioterrorism preparedness efforts with ongoing disease surveillance and outbreak response activities as defined in CDC's emerging infectious disease strategy."[9]

Other estimates of the biological weapons that might be used by states or terrorists illustrate this point. The NATO handbook dealing with biological warfare lists 31 agents. A Russian panel assessing microbiological agents identified 11 that were "very likely to be used." The top four were smallpox, plague, Anthrax, and botulism. These four were chosen because they can all be delivered as aerosols, and have theoretical lethality rates of 30-80%, and smallpox and Anthrax are particularly attractive because they are easy for states to produce in large quantities, and the organism is resistant to destruction. The other items on the list included tularemia, glanders, typhus, Q fever, Venezuelan equine encephalitis, Marburg, and the influenza viruses.[10]

It should be noted that none of these lists include biological weapons directed at livestock or food groups, or the use of "eco-weapons" such as introducing new strains of agricultural disease or new plants, animals, and insects that could exploit vulnerabilities in the ecological balance of the US. There is ample recent experience to show, however, that such attacks occur regularly in the course of nature and as part of global transit and trade, and that they could potentially be highly effective.

The sheer diversity of biological weapons-- and the difficulties in predicting how they will be weaponized and how strains of the disease will have been altered during militarization--

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presents major problems in detecting, characterizing, and responding to such threats, particularly because they may be used in covert attacks. As the CDC notes,[11]

> They present different challenges and require an additional dimension of emergency planning that involves the public health infrastructure Covert dissemination of a biological agent in a public place will not have an immediate impact because of the delay between exposure and onset of illness (i.e., the incubation period). Consequently, the first casualties of a covert attack probably will be identified by physicians or other primary health-care providers. For example, in the event of a covert release of the contagious variola virus, patients will appear in doctors' offices, clinics, and emergency rooms during the first or second week, complaining of fever, back pain, headache, nausea, and other symptoms of what initially might appear to be an ordinary viral infection. As the disease progresses, these persons will develop the papular rash characteristic of early-stage smallpox, a rash that physicians might not recognize immediately. By the time the rash becomes pustular and patients begin to die, the terrorists would be far away and the disease disseminated through the population by person-to-person contact. Only a short window of opportunity will exist between the time the first cases are identified and a second wave of the population becomes ill. During that brief period, public health officials will need to determine that an attack has occurred, identify the organism, and prevent more casualties through prevention strategies (e.g., mass vaccination or prophylactic treatment). As person-to-person contact continues, successive waves of transmission could carry infection to other worldwide localities. These issues might also be relevant for other person-to-person transmissible etiologic agents (e.g., plague or certain viral hemorrhagic fevers).
>
> Certain chemical agents can also be delivered covertly through contaminated food or water. In 1999, the vulnerability of the food supply was illustrated in Belgium, when chickens were unintentionally exposed to dioxin-contaminated fat used to make animal feed (*6*). Because the contamination was not discovered for months, the dioxin, a cancer-causing chemical that does not cause immediate symptoms in humans, was probably present in chicken meat and eggs sold in Europe during early 1999. This incident underscores the need for prompt diagnoses of unusual or suspicious health problems in animals as well as humans, a lesson that was also demonstrated by the recent outbreak of mosquitoborne West Nile virus in birds and humans in New York City in 1999. The dioxin episode also demonstrates how a covert act of foodborne biological or chemical terrorism could affect commerce and human or animal health.
>
> …Early detection of and response to biological or chemical terrorism are crucial. Without special preparation at the local and state levels, a large-scale attack with variola virus, aerosolized anthrax spores, a nerve gas, or a foodborne biological or chemical agent could overwhelm the local and perhaps national public health infrastructure. Large numbers of patients, including both infected persons and the "worried well," would seek medical attention, with a corresponding need for medical supplies, diagnostic tests, and hospital beds. Emergency responders, health-care workers, and public health officials could be at special risk, and everyday life would be disrupted as a result of widespread fear of contagion.
>
> Preparedness for terrorist-caused outbreaks and injuries is an essential component of the U.S. public health surveillance and response system, which is designed to protect the population against any unusual public health event (e.g., influenza pandemics, contaminated municipal water supplies, or intentional dissemination of *Yersinia pestis*, the causative agent of plague [*7*]). The epidemiologic skills, surveillance methods, diagnostic techniques, and physical resources required to detect and investigate unusual or unknown diseases, as well as syndromes or injuries caused by chemical accidents, are similar to those needed to identify and respond to an attack with a biological or chemical agent. However, public health agencies must prepare also for the special features a terrorist attack probably would have (e.g., mass casualties or the use of rare agents) Terrorists might use combinations of these agents, attack in more than one location simultaneously, use new agents, or use organisms that are not on the critical list (e.g., common, drug-resistant, or genetically engineered pathogens). Lists of critical biological and chemical

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> agents will need to be modified as new information becomes available. In addition, each state and locality will need to adapt the lists to local conditions and preparedness needs by using the criteria provided in CDC's strategic plan.
>
> Potential biological and chemical agents are numerous, and the public health infrastructure must be equipped to quickly resolve crises that would arise from a biological or chemical attack. However, to best protect the public, the preparedness efforts must be focused on agents that might have the greatest impact on U.S. health and security, especially agents that are highly contagious or that can be engineered for widespread dissemination via small-particle aerosols. Preparing the nation to address these dangers is a major challenge to U.S. public health systems and health-care providers. Early detection requires increased biological and chemical terrorism awareness among front-line health-care providers because they are in the best position to report suspicious illnesses and injuries. Also, early detection will require improved communication systems between those providers and public health officials. In addition, state and local health-care agencies must have enhanced capacity to investigate unusual events and unexplained illnesses, and diagnostic laboratories must be equipped to identify biological and chemical agents that rarely are seen in the United States. Fundamental to these efforts is comprehensive, integrated training designed to ensure core competency in public health preparedness and the highest levels of scientific expertise among local, state, and federal partners.

Case Studies: Iraq and Russia

There are two nations whose activities in biological warfare have become relatively well known. Table 4.8 shows that Iraq was found to have weaponized a wide range of agents after the Gulf War. The former Soviet Union successfully weaponized some 37 agents before the end of the Cold War, including infectious agents designed to follow up a strategic nuclear attack on the US with contagious diseases designed to decimate the population.[12] According to some sources, it involved some 60,000 to 70,000 people.[13] The agents Russia developed included germ agents such as Anthrax, smallpox, Ebola, Venezuelan encephalitis and genetically engineered bugs for which there is no vaccine or prophylactic treatment.[14] An accidental release of an Anthrax agent in Sverdlovsk in Russia, in 1979, affected an area some three miles downwind from the factory and infected 80-200 Russians. It killed animals in villages as far as 30 miles downwind.[15]

Ken Alibek, a Senior Russian official in the Soviet Union's Bioweapons Directorate program summarizes the effort as follows.[16]

> When I came to the United States we had a lot of discussions on how for example one or another country would be developing biological weapons. And do you know what was interesting to me, it's a widely accepted idea in this country that biological weapons could be developed just in one case; if there is protection or treatment or prophylaxis against one another agent. In the United States, until this country terminated its program, there was a requirement; if there was no treatment or prophylaxis you cannot use a given agent for developing and manufacturing biological weapons. People were trying just to apply exactly

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> the same mentality to other countries involved in developing biological weapons. For example, for the Soviet Union, the best biological weapons were biological weapons without any possible treatment and prophylaxis. Ebola was considered one of the best possible agents for biological weapons; Marburg, smallpox and huge number of attempts to genetically alter diseases like plague, anthrax, tularemia. In the late '80s the country was able to start developing new prototypes of bacterial biological weapons based on multi-resistant strains, meaning that all existing treatments available in the West wouldn't be possible to apply because these agents would overcome antibiotic treatments. We cannot ignore this situation. I'm 100% sure that some biological weapons and their killing capability are more effective than some forms of nuclear weapons

While Russia no longer seems to pose a direct threat to the US, it is important to note that this program may lead to the transfer of critical weapons technologies to state actors or terrorists. An April report by the GAO found that such a threat is all too real:[17]

> The former Soviet Union's biological weapons institutes continue to threaten U.S. national security because they have key assets that are both dangerous and vulnerable to misuse, according to State and Defense Department officials. These assets include as many as 15,000 underpaid scientists and researchers, specialized facilities and equipment (albeit often in a deteriorated condition), and large collections of dangerous biological pathogens. These assets could harm the United States if hostile countries or groups were to hire the institutes or biological weapons scientists to conduct weapons-related work. Also of concern is the potential sale of dangerous pathogens to terrorist groups or countries of proliferation concern. State and Defense officials told us that since 1997, Iran and other countries have intensified their efforts to acquire biological weapons expertise and materials from former Soviet biological weapons institutes. In addition, deteriorated physical safety and security conditions could leave dangerous pathogens vulnerable to theft or distribution into the local environment. Finally, much of the former Soviet biological weapons program's infrastructure, such as buildings and equipment, still exists primarily in Russia. While most of these components have legitimate biotechnological applications, they also harbor the potential for renewed production of offensive biological agents.
>
> …About 50 former Soviet biological weapons institutes continue to exist today—most of which are in Russia. Defense Department officials told us that the Russian Ministry of Defense still manages at least four former Soviet military biological weapons institutes to which Russia has consistently refused to grant the United States access. A senior Science Center official noted that the Russian government has not restricted the Center's access to former Soviet nonmilitary biological weapons institutes that receive U.S. assistance. While the Science Center has funded projects and gained access to more than 30 such institutes, the official noted that at least 15 other nonmilitary institutes have not received Center funding.
>
> The Science Center official also estimated that there may be as many as 5,000 senior former Soviet biological weapons scientists who could pose significant proliferation risks and another 10,000 personnel who have weapons-relevant skills. At the six institutes that we visited in December 1999, institute officials said their institutes had lost as much as one-half of their former workforce but noted that they had released administrative and technical support staff in efforts to retain their senior scientists. The senior Science Center official also said these highly trained senior scientists, many with doctorates or other advanced degrees, represent the intellectual core of the world's largest and most sophisticated biological weapons program.
>
> During our visit to the six institutes, we observed that many of these institutes have retained physical assets that could be applied to biological weapons research. Officials at two of the Russian institutes—the State Research Center for Virology and Biotechnology (Vector) and the State Research Center for Applied Microbiology (Obolensk)—said they continue to conduct research on live pathogens for legitimate purposes. Research on dangerous live pathogens, whether for legitimate or illicit purposes, Several former

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Soviet biological weapons institutes continue to maintain vast collections of dangerous pathogens that could be used for legitimate public health research or for an offensive biological weapons program.

…These threat assets could be misused if third parties obtained access either to the scientists, the institutes, or the pathogens themselves. The assets could also be subject to unauthorized access or used to sustain or renew an offensive biological weapons program. …State, Defense, and Energy Department officials said the dire financial conditions at former Soviet biological weapons institutes could encourage the proliferation of weapons expertise to countries or groups of concern. This proliferation could occur either if former Soviet biological weapons scientists emigrate to countries of proliferation concern in search of higher pay or if such countries or terrorist groups engage impoverished institutes in research that would augment their biological weapons programs. State and Defense officials told us that since 1997 Iran and other countries of proliferation concern have intensified their efforts to acquire biological weapons expertise and materials from at least 15 former Soviet biological weapons institutes.

An unclassified Central Intelligence Agency report notes that these countries and terrorist groups could make dramatic leaps forward in their biological weapons programs by importing talent from Russia.[18] Another unclassified Central Intelligence Agency report notes that Russia is a significant source of biotechnology expertise for Iran and that Russia's world-leading biological weapons program makes it an attractive target for Iranians seeking technical information and training on biological weapons production processes.[19]

Five of the six institute directors told us of significant reductions of funding since the breakup of the former Soviet Union. Officials at Russia's State Research Center for Applied Microbiology told us that their operating budget dropped from about $25 million in 1991 to about $2.5 million in 1999. Institute officials said the actual purchasing power of the scientists' salaries had decreased by more than 75 percent during this time. Numerous senior scientists told us their current salaries ranged from $40 to $80 a month.

Institute officials at the six institutes we visited said most of the scientific staff that had left their institutes had gone to the United States or Europe. Although none of the institute officials reported knowledge of scientists moving to countries of proliferation concern, the former Deputy Chief of Biopreparat and various media reports identify instances in which scientists have moved to such countries. Officials at three institutes we visited reported that, in the past, representatives of countries of proliferation concern had approached them seeking to initiate questionable dual-use research. Officials at the three institutes told us they had refused these offers because of a pledge made to U.S. executive branch officials as a condition of receiving U.S. assistance. The pledge includes avoiding cooperation both with countries of proliferation concern or with terrorist

…Officials from the Departments of State and Defense said they are concerned that dangerous pathogen stocks could be stolen and used for illicit purposes or that an industrial accident could occur. These officials cited a recent nongovernmental report that identified several instances of theft or diversion of dangerous pathogens, including smallpox, plague, and anthrax, from institutes in Russia, Georgia, and Kazakhstan. The Defense Department notes that providing physical security is difficult because of the small size of pathogen vials. Also, pathogens cannot be detected using X-ray machines. For example, a seed culture of dried anthrax spores could be carried in a sealed plastic vial the size of a thumbnail, making detection almost impossible. Also of concern is the potential sale of dangerous pathogens to terrorist groups or countries of proliferation concern.

Although some institutes had impressive equipment and modern facilities, we also observed or often unused. Deteriorated conditions may be compounded by potential human error such as the case of the 1979 accidental release of anthrax from a Soviet military facility in Sverdlovsk, Russia (now Yekaterinburg), which resulted in the deaths of at least 66 people.

…Russia could potentially sustain or renew an offensive biological weapons program by using the former Soviet program's existing human and physical assets, according to State and Defense Department officials. Such assets include the institutes, which supported a covert national offensive biological weapons program

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that continued in spite of the Biological and Toxin Weapons Convention. The Department of Defense has reported 16 that the United States remains concerned about Russia's biological weapons capabilities and its compliance with the Convention. State and Defense officials told us in March 2000 that they remain concerned that offensive research may continue to take place at the Russian Ministry of Defense facilities to which the United States has no access. Another issue of concern is that the leadership of the former Soviet biological weapons program remains largely in place. In a January 2000 report, the Defense Department stated that the same generals who directed the Soviet biological weapons program continue to lead the greatly reduced Russian military defensive biological weapons program, while the same Soviet ex-general continues to direct Biopreparat.

State Actor, Proxy, and Terrorist/Extremist Incidents to Date

While some sources claim that there has been almost no use of biological weapons in covert and terrorist attacks to date, this does not seem to be the case. Work by W. Seth Carus indicates that there are 51 cases of reported biological terrorism, of which 24 involved significant activity and five involved confirmed use. In addition, there are 77 cases of criminal use of biological agents and poisons, 49 of which can be confirmed, and 93 more cases where the perpetrators cannot be characterized clearly as either terrorist or criminals. There are 19 cases involving allegations of covert state activity, of which 11 can be documented.[20]

This does not mean that there have not been many more cases where false reports have been made. Dr. Carus found a total of 234 reported cases, of which 150 involved significant activity. A total of 109 cases out of the 150 involved threats or hoaxes, but 10 involved a serious interest in biological agents, 10 more involved actual efforts to acquire biological agents, and 21 more involved actual acquisition and use. It is interesting to note that 16 of the latter 21 cases of actual use involved criminal activity and only 5 involved terrorism.[21]

The tempo of such activity also seems to be increasing. A total of 33 out of 49 confirmed criminal cases occurred in the 1990s, and 16 out of the 24 confirmed criminal uses. If one includes all possibilities including threats and hoaxes, 123 out of 150 cases occurred in the 1990s, versus 9 during 1980-1989, 8 during 1970-1979, 1 during 1960-1969, 1 during 1950-1959, 1 during 1940-1949, 3 during 1930-1939, 0 during 1920-1929, 3 during 1910-1919, and 1 during 1900-1909.[22] The actual level of casualties, however, has remained limited. Carus estimates that there were 881 casualties as a result of biocrimes and bioterrorism, of which 130 resulted from biocrimes and 751 from one successful incident of bioterrorism. These casualties

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produced only 10 deaths, only one of which has occurred since 1945.[23]

There have been several serious terrorist and extremist efforts to use biological weapons. Germany's Red Army Faction, Italy's Red Brigades, and some Palestinian groups have at least discussed the manufacture and use of chemical and biological weapons. Chemical poisons have been used in ways that skate the definition of biological weapons. Palestinian terrorists once poisoned a shipment of Jaffa oranges from Israel, and a shipment of Chilean grapes shipped to the US was dusted in cyanide. In 1984, a member of the Baghwan Shree Rajneesh cult used salmonella gastroenteritis to poison the salad bars in a town in Oregon and 751 people became ill.[24] In 1989, a cell of the German Baader-Meinhof gang was discovered with a culture of clostridium botulinum.

Aum Shinrikyo is the one known case in which a terrorist/extremist group had vast financial resources and actively attempted to use biological weapons. It is not clear, however, that it represents anything other than a fluke. Few religious extremist movements turn to radical terrorism of the kind that involves the potential use of weapons of mass destruction. Aum's vast financial resources, ability to buy modern equipment, and access to some scientists also do not mean that cult based on a lunatic view of the world sets the standard for effective planning and work efforts.

There are also different views of Aum's success. According to some sources, Aum attempted to acquire the Ebola virus in Zaire, and successfully manufactured and tried to use Anthrax and botulinum in attacks in Japan in 1995.[25] One report even talks about spraying Anthrax from the top of Aum's building in Tokyo for four days. It does seem that Aum attempted some 11 different uses of biological weapons. According to one source, four involved the use of Botulin toxin between April 1990 and March 1995, and against targets such as civilians in Tokyo, US bases in Yokohama, and the airport at Narita. Four involved attacks using Anthrax during the period from late-June through July 1993, and all intended to kill large numbers of civilians in Tokyo.[26]

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Experts debate the extent to which this failure was the result of any inherent problems in manufacturing the agent or limitations in the method of attack, and some feel Aum failed because it used a vaccine strain of Anthrax and a form of Botulism that was very slow to reproduce.[27] Still another source summarizes Aum's efforts as follows: [28]

> The first experiment with this in April 1990 while most of the cult members were on a retreat at an island near Okinawa. One team was left behind expressly for the purposes of experimentally releasing Botulin toxin from a car around the Japanese Parliament building, around the Diet. There were no reports of any casualties, any injuries associated with that release.
>
> Three years later, having worked towards trying to perfect their technology, working out of a new laboratory now, the cult attempted once again to release Botulin toxin. They had modified a truck or a car rather, as a spray vehicle, and this time they were intending to release their Botulin toxin to coincide with the wedding of the Crown Prince. And to that end they drove around the Imperial Palace grounds as well as government buildings in Tokyo. At that time they also visited the US Naval base outside of Tokyo and attempted to release Botulin toxin in that area as well. However, once again there were no health effects associated with that release, at least none that were reported.
>
> In late June of '93, that same month, disappointed perhaps over the inability of their Botulin toxin to effect any lasting effects, the cult attempted to release anthrax spores, or did release anthrax spores, from their office building laboratory in Tokyo itself. Now at the time there were reports of foul smells, brown steam spots on cars and the sidewalk, some pet deaths, plant deaths and what-have-you, but again, no reports of any human casualties associated with that release.

Another source directly contradicts these assertions. It denies that Aum actively sought Ebola or Q-Fever, produced botulinum toxin with any success, or made an effective attempt to use Anthrax. In fact, it claims that Aum attempted to modify an animal vaccine culture.[29] It denies that Aum had any success in genetic engineering and reports that Aum successfully used molecular engineering or reengineered e-coli to place a botulinum toxin inside it.

The most interesting aspect of this view is that it indicates that Aum failed to be successful (a) because it never made many of the reported attempts, and (b) failed because it was so extreme it could not carry out complex efforts efficiently. It is interesting to note in this light that a US Army simulation in the 1960s of the use of Anthrax in the New York subway produced an estimated 10,000 deaths, and one expert estimated that as many as three million might have died if F. tularemia had been used instead.[30]

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The Yugoslav Smallpox Incident

It is interesting to contrast the various views of the Aum experience with a natural outbreak of disease in a developed country, which could just as easily have been the result of a biological attack:[31]

> ...the only guidance we have on what to expect from a smallpox release comes from the experience of two natural outbreaks, one in Germany in 1970, which led to a total of 20 people being infected, and a far worse outbreak in Yugoslavia in 1972...When a pilgrim returned to the famous Kosovo province, he was seen by a number of different friends on return. These friends came from a number of different areas and about two weeks later, a group of cases occurred, eleven cases.
>
> Yugoslavia had seen no smallpox since 1927, so this was 1972, 45 years since they'd had any smallpox. Yugoslavia, like most of Europe, was regularly vaccinating the population, so it was a moderately well vaccinated population. The physicians however, had had no experience in diagnosing smallpox and all of the eleven cases in the first generation were missed. One of the cases was a haemorrhagic case. Haemorrhagic smallpox is very uniformly fatal, within usually five to seven days. The individual normally puts out a great deal of virus, but the diagnosis is often missed. In this case it was a 30-year-old schoolteacher who came down with this disease, was given penicillin; his condition deteriorated, he was moved subsequently to another hospital, a district hospital, finally to the capital city, his blood pressure began to fall, he was evacuated to an intensive care unit, and at the intensive care unit he died. Only two days after his death was it recognized that smallpox was present in Yugoslavia.
>
> That person, that one schoolteacher, infected some 35 others in hospital throughout his stay, including a number of physicians and nurses. And then by the time it was discovered, there were some 150 cases already present in Yugoslavia. The problem that the Yugoslav government was then faced with, as this was reported to other countries, they closed their borders, literally closed their borders -this would be Austria, Italy, Greece -and simply stopped all transport across the border, be it boat or train or plane, Yugoslavia was isolated.
>
> They saw no option but to go ahead and vaccinate the entire country, which they did over a period of some 10 to 12 days, they vaccinated some 19-million people. They were faced with a number of contacts of cases; they wanted to isolate them, so that if they did come down with smallpox they would already be isolated and would not continue to spread the disease. And so they took over whole hotels, apartment blocks, and cordoned them off with barbed wire and police, and admitted the people in to this area for a two-week stay, and no one left those once they were quarantined. And they did this for some 10,000 people.

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Cases in the US

There have been a number of domestic extremist attempts to use such weapons in the US although many were little more than threats and none have been particularly successful. Some food poisoning efforts have succeeded in causing illness, but a few sick and dead scarcely compare with an average of 9,000 deaths from food poisoning a year in the US from natural causes. The FBI reports that:[32]

- 37 cases involving chemical and biological weapons were opened in 1996,
- There were 74 cases opened in 1997, 22 of which were related to biological agents,
- There were 181 cases opened in 1998, 112 of which were biological,
- As of late May 1999, 123 cases had been opened in 1999, 100 of which were biological,
- In 1998 and 1999 combined, over three-quarters of the cases opened threatened the release of biological weapons. The most common threat was Anthrax.

Most of these cases can be dismissed as mere threats and extortion attempts, often by deeply disturbed "loners." FBI sources do indicate, however, that some involve relatively well-equipped home labs, and that there were some successful efforts to produce Ricin, botulinum, and Anthrax.

The Lethality and Effectiveness of Current Biological Weapons

Chart 4.2 shows that biological weapons can be far more lethal than chemical weapons. According to this chart, the lethal dose for botulinum toxin, for example, is 0.001 micrograms per kilogram of body weight, while the lethal dose for VX – the most lethal form of nerve gas – is 15 micrograms per kilogram of body weight. In theory, one milligram of Anthrax spores contains one million infective doses.

Chart 4.3 and Tables 4.7 and 4.8 show that efficient modern biological weapons can also be extremely lethal or merely incapacitating. They can be infectious or transmitted only by

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contact with a wet or dry delivery medium. They can be quick or slow to react, and can be chosen from weapons for which there are well known and proven cures or from weapons for which there is no present vaccine or effective treatment. It should be noted, however, that most of the estimates of the impact of attacks used in this study are drawn from military models where the threat was assumed to be weaponized.

As in the case with chemical weapons any such lethality estimates are extremely uncertain although, the CDC and Defense Threat Reduction Agency (DTRA) are working on more sophisticated classified models. There is no operational experience to back up theoretical estimates, and the limited test data supporting such estimates is often highly dated and has little to do with modern, highly weaponized agents. In many cases, the assumption is made delivery will occur under near optimal conditions but the agent will then behave in a manner that is somewhat similar to a natural epidemic. In the case of biological weapons, however, these uncertainties affect a far wider range of potential casualties.

Anthrax as a Case Example

Johns Hopkins has attempted to create a consensus estimate of the threat posed by key biological weapons, including Anthrax. It was forced to turn to a WHO estimate dating back to 1970 that estimated that the release of 50 kilograms of Anthrax over a developed urban area of 5 million could infect as many as 250,000 people, of whom 100,000 could be expected to die. This same WHO study, however, estimated that in other sections 50 kilograms of Anthrax could kill "only" about 36,000 and incapacitate another 45,000.[33]

A 1993 report by the Office of Technology Assessment of the US Congress estimated that between 130,000 and three million would die following the release of 100 kilograms of aerosolized Anthrax over the greater Washington area with economic costs of $26.2 billion per 100,000 persons exposed. A chart in the same study estimated that 100 kilograms of a 1-5 micron aerosol of Anthrax could killed three million people in the Washington area, versus 750,000-1.9 million for a one-megaton bomb.[34] Other US government studies indicate that it

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could take in excess of 2,000 kilograms of agent to produce the same range of casualties in the OTA study.[35]

These figures illustrate a range of uncertainty in lethality approaching two orders of magnitude- - a range some US Army experts indicate is not atypical of classified studies. The and the risks of basing deterrence, detection, warning, and response on such estimates is also illustrated by the fact that the Soviet release of Anthrax at Sverdlovsk killed only 68 out of only 79 people who became ill although the cloud of the agent might theoretically have killed 100,000 or more. The Soviet government also made only a minimal effort to decontaminate the area and vaccinated only 47,000 of the city's one million inhabitants.

These basic uncertainties regarding lethality are matched by equal uncertainties as to how to measure the area over which an agent has a given degree of effectiveness. Most models assume a symmetrical and relatively even deposit of given amounts of agent over a given in spite of the fact that all operational tests indicate that wind patterns and other factors lead to very irregular patterns of concentration. They also do little more than speculate difficulty of estimating exposure in urban areas where much of the population may stay indoors and where the life and effectiveness of the agent may vary according to the presence of sunlight and heat.[36]

Although Anthrax is the best studied biological weapon, it seems fair to say that the effectiveness of any given weaponization of the agent will only be determined when it is actually used, and that its real world lethality could range from negligible to catastrophic. Furthermore, the weaponized version of Anthrax is inhaled while virtually all cases that occur in nature are cutanenous.

While Iraq produced over 8,000 liters of concentrated Anthrax solution before the Gulf War, there is little practical experience with Anthrax as a human disease. Only 18 cases of **inhalation** have been recorded in the US since 1900 to 1978, two of which were the result of laboratory experiments. In contrast some 2,000 cases of cutaneous Anthrax are reported each year, a total of 224 cases were reported in the US during 1944-1994, and some 10,000 people

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died during an epidemic in Zimbabwe between 1979 and 1985. This helps explain why estimates of the lethality of weaponized inhalational Anthrax have to be based on primate data, and why the range of uncertainty for a lethal dose of a 1-5 micron dry agent ranges from 2,500 to 55,500 spores.[37] The Department of Defense Medical NBC Battlebook does not give lethality data per se, but shows a range of 8,000-50,000 spores for an infective dose.[38]

This leads to equally large uncertainties over detection and treatment, particularly since the Soviet experience in Sverldovsk showed that cases occurred over a period 2 to 43 days after exposure, and primate data indicates that weaponized spores can cause lethal effects 58 to 98 days after exposure. The diagnostics and post mortems at Sverdlovk produced a wide range of symptoms and effects which made diagnosis difficult. If an attack was covert, it is also unlikely that the disease would be recognized quickly. The limited Soviet and Russian experience with the disease indicates that the first stage symptoms are close to those of flu – a problem that could make initial diagnosis difficult. Even if a deliberate early effort is made to use diagnostic testing for Anthrax, it would take 6-24 hours to confirm the disease and the course of the disease normally lasts only three days before death, presenting serious problems in organizing the proper response. A delay of even hours in administering antibiotics can be fatal. [39]

Treatment presents further problems because there are no clinical studies of inhalational Anthrax in human beings, a weaponized agent can be tailored to both increase its lethality and resistance to treatment, and rapid vaccination would not be practical even if the vaccine was known to be effective against the strain used in the weapon. The US vaccine, which may or may not be effective, normally is given in a six dose series and the US does not regard the human-live attenuated vaccine developed by the FSU as safe.

The communicability of a weaponized version of the disease is unclear, and containment and quarantine might be necessary. Serious problems could also arise in dealing with dead bodies since cremation seems to be the only safe form of corpse disposal. [40]

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Botulism as a Case Example

These uncertainties become progressively more serious with less familiar weaponized agents. For example, some US Army experts believe that it takes at least 35 times more Botulinum to create a lethal dose than the US estimates in much of its published lethality data.[41] This uncertainty is of some interest because Iraq produced tons of botulism toxin. (The Medical NBC Battlebook does not give a lethal dose, but states that the infective dose is 0.001 *u*g/kilogram (type A)[42]

There is virtually no empirical data in normal medicine with aerosolized Botulinum toxin, but it is expected to produce symptoms normal to the food borne version. Symptoms could begin anywhere from 24 hours to several days after exposure. The initial symptoms would be those of the flu or cold until more characteristic motor symptoms appeared. The US Army is still investigating a vaccine which counters five of the seven neurotoxins in the disease, and seems to leave significant antibodies for more than year, and the CDC has a vaccine that deals with three out of the seven neurotoxins. A higher risk heptavalent antitoxin for neurotoxins A-G is available from the USAMIRID, but requires a protocol with informed consent.[43]

Plague as a Case Example

Plague is a known natural killer and killed over one-third of the population in the Middle East and Europe in major outbreaks in 541 AD and 1346, and some 12 million people in China and India in 1855. Japan, however, is the only nation known to have tried to use Botulinum in recent combat. Unit 731 dropped plague-infected fleas over China on several occasions and caused some cases of plague, although the true scale of the resulting illnesses and deaths is unknown.[44]

Once again, the little reliable data on lethality and estimates differ sharply. The WHO estimated in 1970 that the release of an aerosol of 50 kilograms of Y Pestis over a city of five million would infect some 150,000 people and kill 36,000 – creating a zone of infection some 10 kilometers long and lasting an hour.[45] The FSU also conducted a massive weaponization effort

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during the Cold War, involving 10 institutes and thousands of scientists.

The US Army experts working on the weapon, however, never succeeded in developing a highly effective agent before they terminated research in 1970. Once again, there are serious questions as to what dose would be lethal and how much agent would be required. The Department of Defense Medical NBC Battlebook does not give lethality data per se, but shows a range of 100-500 organisms for an infective dose.[46]

A military agent would not behave as a normal disease. Most natural cases are caused by infection from fleas or direct contact with the infected, and only 2% of the 390 cases in the US between 1947 and 1996 were the kind of pneumonic plague that would be used in weapons. The most recent cases involving large outbreaks of pneumonic plague date back to outbreaks in Manchuria and India in 1910-1911 and 1920-1921, with one small case in Madagascar in 1997. These cases produced nearly 100% lethality among those infected, but they do not set a clear precedent for understanding the behavior of an aerosol weapon.

What is clear is that warning, detection, and treatment would present major response problems. The signs of plague only develop 1-6 days after infection, with a mean time of 2-4 days. And can initially be confused with a cold or flu. The more severe symptoms are similar to viral pneumonia and might not be seen as plague. There are no widely available rapid diagnostic tests, and it could take many states days to perform a conclusive set of tests. The only vaccine for plague was discontinued in 1999, and was never effective in dealing with pneumonic as distinguished from bubonic plague.

The use of streptomycin and other drugs can be highly effective, but requires treatment to begin within 24 hours of exposure to avoid high lethality rates. There are also strains of Y Pestis that are highly immune to normal treatment and which might be weaponized.[47] The live-attenuated vaccines used in some countries have serious side effects and do not seem effective against aerosol agents, and the formaline-inactivated vaccine produced in the US does not reliably protect animals against aerosols.[48]

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Once again, there is no empirical evidence for judging the infectivity of a weaponized agent, how a cloud of agent would behave, or the real-world lethality of the agent. The disease is so dangerous, however, that immediate decisions would have to be taken as to who to contain and/or quarantine.

Smallpox as a Case Example

Smallpox has not been a disease threat in the US for more that a quarter of a century, but it is highly lethal, with a fatality rate approaching 30% among the non-vaccinated. In theory, it was eradicated in 1977, and only two tightly controlled samples are supposed to exist in the US and Russia. However**,** the FSU evidently was still involved in the large-scale weaponization of the agent in 1980, and a number of developing states began their biological warfare programs in the 1960s and may have retained cultures. US intelligence suspects Iran, Libya, North Korea, and Syria may have retained cultures for military purposes.[49]

At this point in time, there are over 114 million unvaccinated Americans and the value of vaccination over 30 years ago is uncertain. The CDC in the US does have a stockpile of 15 million doses of the vaccine, but only a maximum of 6-7 million doses still seem to be effective.[50] The US Army has, however, contracted with BioReliance to make 300,000 more doses for military use, and Bioreliance is developing an improved vaccine and indicates it has a longer-term capability to make and store 10-15 million doses.[51]

The natural aerosolized version of variola major is vulnerable to heat and humidity, but again there is no way to translate the normal behavior of the disease into the effectiveness of a military agent, or to predict its transmissibility between human beings**,** although each generation of infection can easily expand the number of cases by 10-20 times. It is known that only a few virons are needed to infect a human being and they are only 200 nm in diameter. Once again, there are serious questions as to what dose would be lethal and how much agent would be required. The Department of Defense Medical NBC Battlebook does not give lethality data per se, but shows an *assumed* range of 10-100 organisms for an infective dose.[52]

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Smallpox has an incubation period of 7-17 days, with the normal period beginning around 12 days. It then takes 1-3 days for clear symptoms to appear in the form of typical skin eruptions, followed by a 7-10 day progression of the disease requiring constant isolation and intensive medical treatment.[53] As a result, warning and detection would be difficult, and death usually occurs five or six days after the appearance of the characteristic rash, leaving limited time for treatment. Vaccination is only effective through a maximum of 2-4 days after exposure although the first symptoms do not appear for roughly two weeks, supportive therapy has only moderate effectiveness, and cases require isolation to prevent further transmission of the disease. In one case, a single patient infected people on three floors of a hospital because of transmission through the air vents. Decontamination is difficult and must be very thorough. [54]

The problem of deciding who to contain and/or quarantine would again force largely speculative decisions.

Detect, Defend, and Respond to What?

The sheer range of uncertainty in such estimates creates massive problems in judging the priority the US should give to defense against biological weapons, deterring and retaliating against their use, and developing suitable response measures. Even if such weapons are not developed in ways that deliberately defeat current vaccines and medical treatment, many forms of biological attacks, and some chemical attacks as well, would present major problems in terms of effective medical treatment.

A recent GAO study concludes that this would be true even if the biological agent was a relatively well-known weapon like Anthrax:[55]

> Medical preventive measures and treatments are available for some but not all chemical and biological agents. Early treatment following exposure to chemical agents is critical. The availability of effective medical defenses from or treatments for a chemical or biological agent could be a risk factor and influence terrorists' choice of weapon. The lack of an effective vaccine or antibiotic antiviral treatment for biological agents or of an antidote for chemical agents would pose a potential public health challenge but also pose a significant risk for terrorists as well. In the absence of medical defenses, a chemical or biological agent if effectively acquired, processed, and disseminated could become a more desirable choice because it might result in greater casualties. However, processing, testing, and disseminating the agent could equally

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endanger terrorists because they, too, would have no effective protection against the agent.

Medical and biological warfare experts agree that anthrax when inhaled is an agent of concern due in large part to the difficulty of diagnosis and treatment once symptoms appear and its very high lethality. We recently testified on DOD's anthrax vaccination program, pointing out that

- the anthrax vaccine is effective for preventing anthrax infections through the skin such as those sometimes contracted by unprotected workers who handle wool and hides and
- the vaccine appears to be effective against inhalation anthrax in animal species for some, but not all, strains.

However, due to the absence of known correlates of immunity, the results of the animal studies cannot be extrapolated with certainty to humans. DOD is in the process of vaccinating military personnel against anthrax. The efficacy of the vaccine for inhalation anthrax in humans has not been proven. According to CDC, supplies of the plague vaccine do not exist in the United States; however, small supplies of killed plague vaccine may exist in Australia and the United Kingdom. CDC does not consider a vaccine useful to control an outbreak nor protect a population against a terrorist incident.

Further, there are no vaccines for other potential biological agents such as Ebola and other hemorrhagic fevers, brucellosis, glanders, or staphylococcal enterotoxin B. Post- exposure treatment for inhalation anthrax consists of using the vaccine and the antibiotic ciproflaxin, but treatment must begin immediately after exposure and before the influenza-like symptoms appear...Because the symptoms mimic common influenza, proper diagnosis may come too late for effective treatment. ...DOD believes it is prudent to vaccinate U. S. military forces against anthrax exposure, even though efficacy for inhalation anthrax has been based on animal testing.

Similarly, there are no specific antidotes for a number of chemical agents such as the toxic industrial chemicals chlorine and phosgene. Treatment for exposure to these chemical agents consists largely of decontamination, first aid, and respiratory support. An antidote kit comprised of amyl or sodium nitrite exists for hydrogen cyanide. Appendixes I and II contain information on medical treatments for chemical and biological agents, respectively.

Prevention and treatments are available for a number of other agents. For example, there is an effective vaccine for known strains of smallpox, and there are new investigative vaccines for several other possible biological agents, including botulinum, Q fever, Venezuelan equine encephalitis, and tularemia. Antidotes such as atropine, pralidoxime chloride, and diazepam can be used to counteract the effects of a number of chemical nerve agents. The treatment for some chemical and biological agents includes respiratory support with a ventilator. The types and quantities of vaccines, pharmaceuticals, and other items that should be available in the event of a chemical or biological attack can be determined through a methodologically sound threat and risk assessment.

Means of Delivery

Some of these issues become clearer after a review of different means of delivery. Unlike chemical weapons and most nuclear weapons, biological agents generally are compact and low in weight. They can be disseminated in a wide number of ways – such as insects, the

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contamination of water and food supplies, contact, spreading powers or liquids, and by aerosol. The Department of Defense reports that dissemination of infectious agents through aerosols, either as droplets from liquid suspensions or by small particles from dry powders, is by far the most efficient method.[56] Tests conducted during the 1950s and 1960s showed that an aerosol cloud of fine (2-5 microns) particles behaves more like a gas than a suspension, and penetrates interior spaces as well as exterior spaces. The US found that release from ships, aircraft, and tall buildings could achieve some lethality over distances of 50-100 miles, although without anything approaching uniform density.[57]

The military means for delivering biological weapons include artillery, missiles, and aerial sprayers. There are two basic types of actual munition: point source bomblets and line source tanks. Within each category there can be multiple shapes and configurations. BW munitions and delivery systems are very interdependent; frequently, the munition dictates the delivery system. With the evolution of sophisticated line source hardware, the agent, the munition, and delivery system must be carefully integrated. Like chemical weapons, the effectiveness of BW munitions is very dependent on meteorological conditions and many are also sensitive to exposure to daylight.

Covert attacks against the American homeland could involve a wide range of different methods of delivery. They could include disseminating agents through contact, using the wind or spreading them from high buildings, crop sprayers, commercial aircraft, and helicopters. Arthropod vectors and the contamination of food and water supplies could be significant modes of dissemination for BW agents. So could contamination of food and water supplies or aerosol dissemination since only relatively small quantities of relatively impure agent are required for terrorist use, the range of possible agents is almost unlimited.

The Department of Defense estimates indicate the quantity of an agent could be small (a single gram, possibly less). Production and purification methods and dissemination means could range from simple to complex. All of the elements of such a program might go undetected until use has occurred. Broad areas or individual buildings are potential targets. In the case of

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buildings, off-the-shelf aerosol generators could be used to disperse a BW agent into the air inlet ducts of the target structure, especially in the case of toxins, in that much less toxic agents could be employed and/or that quantities of agent required would be much less than for other targets.

Attacks could involve a *mix* of different biological weapons that each required radically different treatment. Because some weapons take a long time before their effects are clear, attacks using multiple agents of "cocktails" could be carried out over days or weeks before their nature and impact became clear, and attacks on agriculture or humans could be masked as the natural outbreak of disease. Accidental "attacks" on American agriculture have been common, and have often had a major impact. Such "attacks" have consisted of importing the wrong pet, diseases brought in the form of a few infected animals or plants, and insects and parasites that have arrived in on birds, aircraft, cars, and ships. These have all had a major impact on given crops, and have affected the ecology of whole states, particularly in the southern and western US and Hawaii. The potential lethality of such attacks is further illustrated by the costs of "mad cow" disease (variant Cruzfeldt Jakob disease or VCJD) in Europe, and the fact that one infected pig could destroy an entire swine industry in Taiwan. Such a form of delivery offers many advantages: it could be virtually undetectable, it could be unattributable and it might never been seen as a deliberate attack, and the effects could be lasting and nation-wide.

Manufacturing Biological Weapons

The manufacture of highly effective biological weapons to use against humans does, however, present significant problems. Producing such weapons is not a problem for most governments, but the ease with which most domestic or foreign terrorists/extremists can obtain or manufacture such weapons has sometimes been exaggerated.

A recent GAO analysis of the issue found that,[58]

> According to experts in the many fields associated with the technical Biological Agents aspects of dealing with biological agents, including those formerly with state- sponsored offensive biological weapon programs, terrorists working outside a state- run laboratory infrastructure would have to overcome extraordinary technical and operational challenges to effectively and successfully weaponize and deliver a biological agent to cause mass casualties. Terrorists would require specialized knowledge from a wide

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range of scientific disciplines to successfully conduct biological terrorism and cause mass casualties. For example, biological agents have varying characteristics.

Information and technical data from these experts, intelligence, and authoritative documented sources indicate that some biological agents such as smallpox are difficult to obtain. In the case of other biological agents such as anthrax land tularemia (both of which are bacteria), it is difficult to obtain a virulent strain (one that causes disease and injury to humans). Other agents such as plague are difficult to produce. Biological toxins such as ricin require large quantities to cause mass casualties, thereby increasing the risk of arousing suspicion or detection prior to dissemination. Furthermore, some agents such as Q fever incapacitate rather than cause death. Finally, many agents are relatively easy to grow, but are difficult to process into a form for a weapon.

…According to experts from former biological warfare programs, to survive and be effective, a virulent biological agent must be grown, handled, and stored properly. This stage requires time and effort for research and development. After cultivation, the agent is wet. Terrorists would need the means to sterilize the growth medium and dispose of hazardous biological wastes. Processing the biological agent into a weaponized form requires even more specialized knowledge.

According to a wide range of experts in science, health, intelligence, and biological warfare and the technical report we reviewed, the most effective way to disseminate a biological agent is by aerosol. This method allows the simultaneous respiratory infection of a large number of people. Microscopic particles that are dispersed must remain airborne for long periods and may be transported by the wind over long distances. The particles are small enough to reach the tiny air sacs of the lungs (alveoli) and bypass the body's natural filtering and defense mechanisms.

According to experts, if larger particles are dispersed, they may fall to the ground, causing no injury, or become trapped in the upper respiratory tract, possibly causing infections but not necessarily death. From an engineering standpoint, it is easier to produce and disseminate the larger particles than the microscopic particles. Other critical technical hurdles include obtaining the proper size equipment to generate proper size aerosols, calculating the correct output rate (speed at which the equipment operates), and having the correct liquid composition.

According to key experts with experience in biological warfare, biological agents can be processed into liquid or dry forms for dissemination. Anthrax is the disease caused by the biological agent Bacillus anthracis. Throughout the report we use the related disease term when referring to biological agents. We found that the disease term is used synonymously with the biological agent in discussions with the many experts we interviewed and documentation we reviewed.

They pose difficult technical challenges for terrorists to effectively cause mass casualties. These experts told us that liquid agents are easy to produce. However, it is difficult to effectively disseminate aerosolized liquid agents with the right particle size without reducing the strength of the mixture. Further, the liquid agent requires larger quantities and dissemination vehicles that can increase the possibility of raising suspicion and detection. In addition, experts told us that in contrast, dry biological agents are more difficult to produce than liquid agents, but dry agents are easier to disseminate.

Dry biological agents could be easily destroyed when processed, rendering the agent ineffective for causing mass casualties. A leading expert told us that the whole process entails risks. For example, powders easily adhere to rubber gloves and pose a handling problem. Effectively disseminating both forms of agent can pose technical challenges in that the proper equipment and energy sources are needed. A less sophisticated product and dissemination method can produce some illness and/ or deaths. DOD classified further details on technical challenges of effectively processing and disseminating biological agents.

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According to the experts we spoke with, exterior dissemination of biological agents can be disrupted by environmental (e. g., pollution) and meteorological (e. g., sun, rain, mist, and wind) conditions. Once released, an aerosol cloud gradually decays and dies as a result of exposure to oxygen, pollutants, and ultraviolet rays. If wind is too erratic or strong, the agent might be dissipated too rapidly or fail to reach the desired area. Interior dissemination of a biological agent through a heating and air conditioning ventilation system could cause casualties. But this method also has risks. Security countermeasures could intercept the perpetrators or apprehend them after the attack. Successful interior dissemination also requires knowledge of aerodynamics. For example, the air exchange rate in a building could affect the dissemination of a biological agent. Regardless of whether a liquid or dry agent is used in interior or exterior environments, experts believe that testing should be done to determine if the agent is virulent and disseminates properly. The numerous steps in the process of developing a biological weapon increase the chances of a terrorist being detected by authorities.

The Advisory Panel to Assess Domestic Response Capabilities for Terrorism Involving Weapons of Mass Destruction drew somewhat similar conclusions:[59]

...the situation now facing a terrorist, who may seek to use a CBRN weapon to achieve mass effects, could change dramatically because of new discoveries, further advances in technology, or other material factors. This is particularly true with respect to potential improvements in aerosolization techniques and processes; advances in the isolation, purification, stability, and quality of certain biological strains; or enhancements to delivery devices, such as nozzles or other sprayers. Future progress in any two or more areas would be especially troubling.

...There are at least four primary acquisition routes that terrorists could conceivably pursue in acquiring a biological warfare capability. They are purchasing a biological agent from one of the world's 1,500 germ banks, as Larry Wayne Harris did; theft from a research laboratory, hospital, or public health service laboratory, where agents are cultivated for diagnostic purposes; isolation and culturing of a desired agent from natural sources; or obtaining biological agents from a rogue state, a disgruntled government scientist, or a state sponsor.

The principal obstacle is less the development of a biological agent than the development of a genuinely lethal strain of the agent in sufficient quantities to cause mass casualties-precisely as Aum's experience indicates. Acquiring the "most infectious and virulent culture for the seed stock is the greatest hurdle," a former senior official in the U.S. military's biological warfare program maintains.

As Aum clearly demonstrated, this is not an easily surmountable obstacle. The most obvious route would be by attempting to acquire the strain from nature, e.g., obtaining potentially lethal anthrax spores from soil and then culturing sufficient quantities to produce mass casualties. While theoretically conceivable, this is nonetheless difficult in practice and doubtless well beyond the capabilities of most terrorist groups.

Acquiring a biological agent of sufficient virulence is only one of the prerequisites for conducting biological terrorism on a mass scale. As Ken Alibek, one of the former Soviet Union's leading biological weapons scientists has argued, the "most virulent culture in a test tube is useless as an offensive weapon until it has been put through a process that gives it stability and predictability. The manufacturing technique is, in a sense, the real weapon, and it is harder to develop than individual agents."

...Airborne viral agents, in particular, are extraordinarily difficult to work with, since the mass production, packaging, and storage of viruses are by themselves difficult and complicated tasks, demanding advanced biotechnical skills, in addition to the attendant risks to personnel involved in the process. In the specific case of botulinum toxins, there are difficulties in purifying these agents, which then will likely become

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unstable once they are purified. According to one biological warfare authority, “maintaining the high toxicity in the culture and the properties of the toxin as you purify it are what you have to have a lot of years [of experience] to know how to do.”

The same problem of maintaining toxicity during the purification process hampered U.S. government researchers during the Cold War. They discovered that attempting to achieve 95 percent purity of a biological agent-the level needed to render it effective as a weapon-in turn reduced the bulk amount of the toxin by 70-80 percent.

Producing other types of bioterrorism agents similarly requires training, advanced techniques, and specialized equipment. In the case of B. anthracis, for example, transforming the bacterium into spore form suitable for use in a wide-scale terrorist attack necessitates a combination of skill and extreme care during a production technique that involves the application of heat or chemical shock. During all stages of the process, B. anthracis, like all other biological agents, must also be continuously tested to ensure its purity and lethality and thus its utility for weapons purposes. Although small-scale laboratory testing might be concealed, any larger-scale tests will likely invite the attention of law enforcement or intelligence agencies.

Indeed, any group aiming at developing a weapon capable of inflicting mass casualties would almost certainly require sophisticated, though not exotic, laboratory equipment. According to the Central Intelligence Agency, this would include “fermenters, large-scale lyophilizers or freeze dryers, class II or ill safety hoods, High-Efficiency Particulate Air (HEPA) filters, and centrifuges.”

Estimates for the cost of equipping a facility for the production of biological agents for mass-casualty terrorist operations vary widely but would likely seem to fall anywhere in the $200,000 to $2 million range-certainly not trivial sums. Although there remains a widespread public perception that it is easy to acquire and use highly lethal biological agents, there is no clear consensus among analysts about how much scientific and technological expertise and prior training are needed. Some authorities maintain that having an “experimental microbiologist and a pathologist, or someone who combines these capabilities, would be crucial [s]upplemented with a little help and advice from an aerosol physicist and a meteorologist.”

Other experts are even more conservative in their assessments. In their view, the creation of a mass-casualty biological weapon would entail scientific teams composed of persons highly trained in “microbiology, pathology, aerosol physics, aerobiology, and even meteorology.”

The acquisition of dedicated staff with the appropriate scientific and engineering knowledge and credentials may, therefore, be the greatest hurdle to developing an effective biological terrorism capability. Finding trained and skilled personnel, who could also overcome obstacles of perhaps working in less-than-ideal environments and who are willing to participate in mass murder, is a profound organizational roadblock, inherent to terrorist development of biological weapons, that is perhaps too readily discounted.

In addition, the paranoid, stressful, and fantasy-prone atmosphere almost certain to be present in a terrorist organization most likely to seek to acquire biological weapons would make it difficult for personnel to perform efficiently the careful and demanding work required for a successful program. In the case of Aum, the atmosphere within the cult, characterized by extreme paranoia, intense stress, and widespread delusion, likely contributed to its failure to develop an effective biological weapons capability. That atmosphere could exist in any number of potential terrorist organizations with similar intentions or motivations.

Finally, terrorists intent on inflicting hundreds of thousands of casualties with biological agents would have to create an aerosol cloud to disseminate the toxin. Aerosol clouds can be created from biological agents in either a mud-like liquid (“slurry”) form or in a dried, talcum powder-like form. The latter is far more difficult. In the case of B. anthracis, turning the spores into a powder requires the use of large and

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expensive centrifuges and drying apparatus. Powder, moreover, clings to surfaces, making it both difficult to handle and more probable that those handling it will accidentally infect themselves.

In addition, the drying process needed to create a pathogenic powder tends to kill inordinate amounts of the organisms. The use of slurry, on the other hand, while less technically challenging, still presents significant problems. For example, the slurry must be continuously refrigerated until it is used, and unless it is extremely pure, material is likely to settle at the bottom of a container and clog the sprayer or aerosol dissemination device. As is detailed below, this is precisely what happened when Aum Shinrikyo members sprayed what they believed to be a lethal strain of B. anthracis from the roof of a Tokyo building in 1993. A slurry concoction is also tricky to disseminate as an aerosol of particles of an optimal size--in other words, that will readily be inhaled into the victims' lungs. Disseminating particles of the proper size (1-5 microns) is critical to the success of any large-scale attack. Building a disseminator capable of dispersing 1- to 5-micron particles in dry form would, however, be a major technical hurdle for any prospective biological terrorist.

That being said, the dissemination itself could conceivably be physically accomplished in any number of different ways: from low-flying airplanes, crop dusters, trucks equipped with sprayers, or with an aerosol canister situated in one place and activated by a remote timing device.

Even if a terrorist group succeeded in producing a virulent biological agent, even if it conducted rigorous tests to ensure that virulence was maintained, and even if it prepared the agent properly for aerosolization and acquired the proper equipment with which to disseminate it, at least one major hurdle would remain. As bioagents are aerosolized and become airborne, they decay rapidly. It is estimated, for example, that 90 percent of the microorganisms in a slurry are likely to die during the process of aerosolization.

…In sum, while the technical challenges in producing an effective biological weapon are not insurmountable, they are neither as straightforward nor as simple as has often been claimed and presented publicly. The latter view, based on the limited information previously available, has heretofore primarily served as the basis for the public and for many decision makers to draw conclusions about the direction of related public policy. The level of difficulty was in fact what Aum discovered for itself and why it elected to pursue, in tandem with its continuing biological weapons R&D program, a concerted and even more expensive effort to produce chemical weapons.

Moreover, as previously mentioned, the requirements to amass personnel, money, facilities, equipment; to conduct testing; and to execute related logistics tasks, will materially increase the risk of exposure to detection by intelligence and law enforcement agencies.

Changes in Technology and the Difficulty of Manufacture

These cautions are useful, but it must be stressed that these comments on the difficulties in manufacturing biological weapons apply largely to attacks on human beings by either individuals or terrorist and extremist groups working without the aid of a state.

They also reflect to the current state of the art in biotechnology. The steady dissemination of the required technology and equipment is reducing the problems in making biological weapons. For example, a recent survey of 1400 US academic institutions found that 16%

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possessed human, animal, or plant pathogens that appear **on** the draft Biological Weapons Convention's list of biological agents. Another 11% have high-level containment facilities, 7% conduct research on vaccines, 5% perform research for the military or Department of Energy to develop defenses against biological weapons, and 3% have high volume bioreactors.[60]

In the 25 years that have followed the development of recombinant DNA technologies, over 2,000 firms have been founded in the US alone. More generally, there are roughly 1,308 US companies now actively commercializing biotechnology. They employ 108,000-116,000 people, and the market for such products is estimated to grow from $7.6 billion in 1996 to $24 billion in 2006. These figures do not include the growth of agriculture biotechnology**,** which may be as much of a source of threats as the technology tailored to deal with humans, and which is expected to grow from $295 million in 1996 to $1.74 billion in 2006. Unlike most companies, such firms also train a large number of individuals in research and development. Biotech firms spent $69,000 per employee on R&D in 1995, versus a US corporate average of $7,651.[61] While there are no precise figures, much of this activity involves foreign scientists and technical personnel.

Other regions are not yet as advanced. For example, Japan is estimated to lag roughly 10 years behind the US in biotechnology (a factor to be considered in assessing Aum Shinrikyo), but the volume is growing. Japan's pharmaceutical market is now worth about $37 billion. Europe is also experiencing significant growth. The number of biotechnology firms grew from 486 in 1994 to 584 in 1995, and the number of employees grew from 16,100 to 17,200. What is more significant is that spending on R&D increased by 21% in one year, to $795 million.[62]

Technology transfer from the former Soviet Union (FSU), however, is a very serious potential problem. The Cold War effort involved some 60,000 to 70,000 people.[63] There is no meaningful current accounting of their whereabouts. It is clear, however, that at least 75,000 Russian scientific workers emigrated between 1989-1992, and many have left since. There are also repeated unconfirmed reports that some of these scientists are working in Iran and North

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Korea.

The Department of Defense has warned that even the production and development of biological weapons by foreign states might not be detected, much less terrorist or extremist groups:[64]

> ...A state might elect to build large-scale facilities unique to this function, as was done in the United States prior to 1969. Such facilities would be, in principle, more susceptible to detection. However, there is no requirement to do this. The lower cost (by a considerable margin) and less readily observable approach would be to employ an in-place civilian facility as the site for agent production.
>
> Production equipment will vary, depending on the quantity of material desired, the methods selected for production, and the agent selected. Unlike CW agents, where production is measured in the tons, BW agent production is measured in the kilograms to tens of kilograms. Assessments of BW verification sometimes assume that the problem is to detect production of as little as 10 kilograms of BW agent.
>
> There is nothing unique about the types of equipment (or technology) that might be employed in a BW program. For example, biological safety cabinets have been adopted universally for biomedical research as well as commercial production of infectious disease products, reagents, and so forth. Fermenters, centrifuges, purification, and other laboratory equipment are used not only by the biomedical community, but have other academic and commercial applications as well, such as wineries, milk plants, pharmaceutical houses, and agricultural products. Production of beer, antibodies, enzymes, and other therapeutic products, such as insulin and growth hormone, involves the use of fermenters ranging in size from 10,000 to 1 million liters; such fermenters could produce significant quantities of BW agent. Key technologies have an intrinsic dual-use character.

The problem in detection would be compounded by the fact that neither states nor independent groups have to adopt the safety procedures used by the US. Department of Defense reporting also notes that while the US developed elaborate containment facilities for conducting infectious disease research at facilities like the Fort Detrick Biological Warfare Research and Development Laboratories during the Cold War, “Other countries do not necessarily share these safety concerns.”[65] Iraq did not follow such procedures, and did not provide all of its dispersed biological weapons with guards or special security storage arrangements during the Gulf War.

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The Growing Lethality of Biological Weapons and Growing Ease of Manufacture

Biological weapons also represent an area where the rapid pace of technical change creates the ability to make far more effective weapons. Biotechnology can offer many benefits.[66] At the same time, genetic engineering and other new technologies can now be employed to overcome product deficiencies in the classic agents and toxins normally addressed in such discussions. Moreover, toxins that exist in nature in small amounts were once considered not to be potential threat agents because of their limited availability. Today, the Department of Defense estimates that a number of natural toxins could be produced through genetic engineering techniques in sufficient quantities for an adversary to consider producing them as an offensive weapon. There are many microorganisms, or their metabolic byproducts (toxins) that can now meet all of the criteria for effective BW agents.[67]

Studies like those of the Jason project indicate that this situation will become much worse in the future. Genetically engineered pathogens can be designed to have any or all of the following attributes:[68]

- *Safer handling and deployment,* including the elimination of risks from accidents or misuse – the "boomerang effect".
- *Easier propagation and/or distribution* eliminating the need for a normally-hydrated bioagent or any use of aerosols. Microorganisms with enhanced aerosol and environmental stability.
- *Improved ability to target the host,* including the possible targeting of specific races or ethnic groups with given genetic characteristics.
- *Greater transmissivity and infectivity:* Engineering a disease like Ebola to be as communicable as measles. Microorganisms resistant to antibiotics, standard vaccines, and therapeutics.
- *New weapons:* Benign microorganisms, genetically altered to produce a toxin, venom, or bioregulator.
- *Increased problems in detection:* Immunologically altered microorganisms able to defeat standard identification, detection, and diagnostic methods. Problems in diagnosis, false diagnosis, lack of detection by existing detectors, long latency, binary initiation.
- *Greater toxicity, more difficult to treat:* Very high morbidity or mortality, resistant to know antibacterial or antiviral agents; defeats existing vaccines; produces symptoms designed to saturate

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available specialized medical treatment facilities.

- *Combinations of some or all of the above.*

New Types of Biological Weapons

While any such analysis is speculative, scientists postulate that the following new types of biological weapons are now deployable or can be manufactured during the coming decade:[69]

- *Binary biological weapons* that use two safe to handle elements which can be assembled before use. This could be a virus and helper virus like Hepatitis D or a bacterial virulence plasmid like E. coli, plague, Anthrax, and dysentery.

- *Designer genes and life forms*, which could include synthetic genes and gene networks, synthetic viruses, and synthetic organisms. These weapons include DNA shuffling, synthetic forms of the flu – which killed more people in 1918 than died in all of World War I and which still kills about 30,000 Americans a year – and synthetic microorganisms.

- *"Gene therapy" weapons* that use transforming viruses or similar DNA vectors carrying Trojan horse genes (retrovirus, adenovirus, poxvirus, HSV-1). Such weapons can produce single individual (somatic cell) or inheritable (germline) changes. It can also remove immunities and wound healing capabilities.

- *Stealth viruses* can be transforming or conditionally inducible. They exploit the fact that humans normally carry a substantial viral load, and examples are the herpesvirus, cytomegalovirus, Epstein-Barr, and SV40 contamination which are normally dormant or limited in infect but can be transformed into far more lethal diseases. They can be introduced over years and then used to blackmail a population.

- *Host-swapping diseases:* Viral parasites normally have narrow host ranges and develop an evolutionary equilibrium with their hosts. Disruption of this equilibrium normally produces no results, but it can be extremely lethal. Natural examples include AIDS, hantavirus, Marburg, and Ebola. Tailoring the disruption for attack purposes can produce weapons that are extremely lethal and for which there is no treatment. A tailored disease like AIDS could combine serious initial lethality with crippling long-term effects lasting decades.

- *Designer diseases* involve using molecular biology to create the disease first and then constructing a pathogen to produce it. It could eliminate immunity, target normally dormant genes, or instruct cells to commit suicide. Apoptosis is programmed cell death, and specific apoptosis can be used to kill any mix of cells.

Changes in Disease: Piggybacking on the Threat from Nature

Alternatively, an attacker might take advantage of the fact that the world – and Americans – are under constant natural attack from evolution. A recent national intelligence

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estimate found that at least 20 well-known diseases had emerged in resistant form during the last 20 years, including tuberculosis, malaria, and cholera.[70] The strains of streptococcus pnemoniae, staphylococcus aureus, and mycobacterium tuberculosis in the US are now 10-35% immune to treatment.

At least 30 previously unknown diseases have emerged since 1973, including HIV, Ebola, Hepatitis C, and Nipah virus for which there are no known cures. As a result, the annual deaths from infectious diseases in the US have doubled to 170,000 a year from their historic low in 1980. Many have been caused by new immigrants such as West Nile virus. Europe continues to suffer from new zoonotic diseases like Creutzfeldt-Jakob or "mad cow disease," which have had massive economic consequences even with minor human losses. (A total of 70 deaths have occurred over a period of six years, with some seven additional cases still alive.)[71]

To put these trends in perspective, 890,000 Americans are now infected with HIV/AIDS, 4 million are chronic carriers of Hepatitis C, 27,000 a year now catch TB – which is 32-52% resistant to established drugs – and 14,000 a year die of streptococcus pnemoniae and staphylococcus aureus. The flu now kills about 30,000 Americans a year – twice the number as in 1972-1984. Experts at the US Center for Disease Control predict a new epidemic – similar to the one that killed 500,000 Americans in 1918 – could kill 197,000-227,000 in spite of improvements in medical treatment.[72]

Much more massive outbreaks of resistant diseases are taking place outside the US, and TB, malaria, hepatitis, and HIV/AIDS continue to surge. For example, roughly 700,000 died from AIDS in 1993, and 2.3 million in 1998. There were an estimated 5.8 million infections and many in developed countries: the HIV population in Russia could reach one million by 2000, and double by 2002. There were 33.4 million people infected with AIDS in 1998, and there will probably be 40 million by the end of 2000.

The inability to predict the impact of even a well-established disease is illustrated by the fact that the World Health Organization (WHO) predicted that deaths from HIV/AIDS would

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peak in 2006 with 1.7 million deaths, and the death rate was already 2.3 million in 1998. The cumulative global economic cost of AIDS is already estimated to have reach $500 billion.[73]

The WHO has warned that "globalism" means that developed countries like the US are becoming progressively more vulnerable to the new variants of disease emerging in the developing world,[74]

> … wealthy countries which have exclusively focussed efforts on fighting disease within their own borders, while failing to help eliminate them globally. Proliferating elsewhere, many bacteria, viruses and parasites mutate, become drug resistant and venture back to wealthy countries via modern transportation.
>
> Resistance is also seen where health workers have exclusively focussed on providing drugs for their patients while inadvertently failing to take time to ensure proper diagnosis, prescription and adherence to treatment.
>
> Antimicrobial resistance is a natural biological phenomenon. But it becomes a significant public health problem where it is amplified many-fold owing to human misuse and neglect. Drug resistance is the most telling sign that we have failed to take the threat of infectious diseases seriously. It suggests that we have mishandled our precious arsenal of disease-fighting drugs, both by overusing them in developed nations and, paradoxically, both misusing and under using them in developing nations. In all cases, half-hearted use of powerful antibiotics now will eventually result in less effective drugs later.
>
> This report describes the growing threat of antimicrobial resistance. It documents how once life-saving medicines are increasingly having as little effect as a sugar pill. Microbial resistance to treatment could bring the world back to a pre-antibiotic age.
>
> Before long, we may have forever missed our opportunity to control and eventually eliminate the most dangerous infectious diseases. Indeed, if we fail to make rapid progress during this decade, it may become very difficult and expensive – if not impossible – to do so later. We need to make effective use of the tools we have now.
>
> The eradication of smallpox in 1980, for example, happened not a moment too soon. Just a few years' delay and the unforeseen emergence of HIV would have undermined safe smallpox vaccination in populations severely affected by HIV.
>
> While many exciting research efforts are currently underway, there is no guarantee that they will yield new drugs or vaccines in the near future. Since 1970, no new classes of antibacterials have been developed to combat infectious diseases. On average, research and development of anti-infective drugs takes 10 to 20 years. Currently, there are no new drugs or vaccines ready to emerge from the research and development pipeline.
>
> Moreover, for the major infectious killers, research and development funding continues to be woefully inadequate. A very small percentage of all global health research and development funding is currently devoted to finding new drugs or vaccines to stop AIDS, acute respiratory infections (ARI), diarrhoeal diseases, malaria and TB. The pharmaceutical industry reports that it costs them a minimum of US$ 500 million just to bring one drug to market. Combined funding for research and development into ARI, diarrhoeal diseases, malaria and TB last year was under that amount.

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Although prevention through vaccination continues to be the ultimate weapon against infection and drug resistance, no vaccines are available to prevent five of the six major infectious killers. Yet it is a needless tragedy that 11 million people perish each year awaiting the advent of newer miracle drugs and vaccines. Prevention and treatment strategies using tools available now can be provided to populations throughout the world to help eliminate high-burden diseases of poverty.

We need not stand by helplessly watching antimicrobial resistance increase and drug effectiveness decrease. As this report shows, resistance can be contained. When an infection is addressed in a comprehensive and timely manner, resistance rarely becomes a public health problem. The most effective strategy against antimicrobial resistance is to get the job done right the first time – to unequivocally destroy microbes – thereby defeating resistance before it starts.

Today - despite advances in science and technology - infectious disease poses a more deadly threat to human life than war. This year – at the onset of a new millennium – the international community is beginning to show its intent to turn back these microbial invaders through massive efforts against diseases of poverty – diseases which must be defeated now, before they become resistant. When diseases are fought wisely and widely, drug resistance can be controlled and lives saved.

… As early as half a century ago – just a few years after penicillin was put on the market – scientists began noticing the emergence of a penicillin-resistant strain of Staphylococcus aureus, a common bacterium that claims membership among the human body's normal bacterial flora. Resistant strains of gonorrhoea, dysentery-causing shigella (a major cause of premature death in developing countries) and salmonella rapidly followed in the wake of staphylococcus 20 to 25 years later.

From that first case of resistant staphylococcus, the problem of antimicrobial resistance has snowballed into a serious public health concern with economic, social and political implications that are global in scope and cross all environmental and ethnic boundaries. Multi drug-resistant tuberculosis (MDR-TB) is no longer confined to any one country or to those co-infected with HIV, but has appeared in locations as diverse as eastern Europe, Africa and Asia among health care workers and in the general population. Penicillin-resistant pneumococci are likewise spreading rapidly, while resistant malaria is on the rise, disabling and killing millions of children and adults each year. In 1990, almost all cholera isolates gathered around New Delhi (India) were sensitive to cheap, first-line drugs furazolidone, ampicillin, co-trimoxazole and nalidixic acid. Now, 10 years later, formerly effective drugs are largely useless in the battle to contain cholera epidemics.

In some areas of the world – most notably South-East Asia – 98% of all gonorrhoea cases are multi drug-resistant which in turn contributes to the sexual transmission of HIV. In India, 60% of all cases of visceral leishmaniasis – a sandfly-borne parasitic infection – no longer respond to an increasingly limited cache of first-line drugs; while in the industrialized world, as many as 60% of hospital-acquired infections are caused by drug-resistant microbes. These infections – the most recent of which are vancomycin-resistant Enterococcus (VRE) and methicillin-resistant Staphylococcus aureus (MRSA), are now no longer confined to wards but have crept into the community at large.

Although most drugs are still active, the lengthening shadow of resistance means that many of them may not be for long. In the case of tuberculosis, the emergence of multi drug-resistant bacteria means that medications that once cost as little as US$ 20 must now be replaced with drugs a hundred times more expensive. Other diseases are likewise becoming increasingly impervious ….

This illustrates the fact that Homeland defense cannot be separated from public health policy. The effectiveness of treatment for most of these diseases is now forecast to decline over

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the near to mid-term, and humanitarian crises are projected to create a further problem. There were 24 major humanitarian crises in 1999, involving at least 35 million refugees and displaced people. Further, immigration had reached the point where 180 million people lived outside the country of their birth. Roughly 88% of the population growth in Europe in the 1990s came from immigration.[75]

Future attackers could piggyback on the natural evolution of disease to use new or resistant weapons, or genetically engineer diseases that might not be distinguished from a natural outbreak – at least not quickly and in a form where the attacker could not be identified. They could also use stealth attacks and proxies to deliver new or resistant diseases, and the previous data show that some attacks on the US might take years to mature – which makes detection and retaliation extremely difficult.

Agricultural and Ecological Attacks

As has been touched upon earlier, the uncertainties surrounding biological attacks on human beings are compounded by the risk of biological attacks on crops and livestock, which could be combined with attacks on human beings. Agriculture accounts for 13% of the US GNP, and 17% of total employment (860,000 jobs) although less than 2% of the US work force is on farms. [76] The US exports well over $140 billion worth of agricultural goods annually. The US also has special regional and local vulnerabilities. Some 84% of its cattle are in the southwest, 60% of swine are in the northeast, and 78% of chickens are in the southeast Atlantic region. Some feedlots hold 150,000 to 300,000 cattle and 78% of all cattle pass through only 2% of the feedlots. Some pig farms hold 10,000 hogs and chicken farms pen over 100,000 birds.[77]

A study the US Department of Defense issued in January 2001 notes that,[78]

> The potential threats to U.S. agriculture and livestock can come from a variety of pathogens and causative agents. With one in eight jobs and 13 percent of the gross national product dependent on U.S. agricultural productivity, economic stability of the country depends on a bountiful and safe food supply system. Similar to the human population, the high health status of crop and livestock assets in the United States creates a great vulnerability to attack with biological agents. Attacks against U.S. agricultural assets, might

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be tempting, due to the perceived relative ease of attack, the plausible deniability toward accusations, and the limited number of plant seed varieties in use. Indeed, the Soviet Union apparently planned to target U.S. agriculture and livestock as one element of a larger disruptive process and developed a range of biological agents that would be effective in this capacity

Consequences of compromising the productivity and safety of the U.S. food supply are primarily economic in nature. Disrupting the supply lines for food stocks or threatening the safety of those items supplied also may erode military readiness.

Highly infectious naturally occurring plant and animal pathogens exist outside the U.S. borders and some agents are readily transported, inadvertently or intentionally, with little risk of detection. The Animal and Plant Health Inspection Service (APHIS) is the regulatory, first-response agency responsible for the diagnosis and management of all suspicious agricultural disease outbreaks. As a result of binding international agreements, select plant and animal disease outbreak confirmation, regardless of magnitude, can immediately have an impact on export trade. Depending on the agent, APHIS authority includes property seizure and total eradication of all plant or animal hosts within concentric zones of quarantine. Public trust in government and political stability can be threatened depend-ing on the extent of disease transmission, the success of regulatory response procedures, and the duration of time to restore normalcy. Additional impacts include:

U.S. livestock markets would be vulnerable to the causative agents of diseases including anthrax, Q fever, brucellosis, FMD, Venezuelan equine encephalitis, hog cholera, African swine fever, avian influenza, Newcastle disease, Rift Valley fever, and rinderpest.

Soybean rust, which can easily be introduced and spreads quickly, could cause U.S. soybean producers, processors, livestock producers, and consumers to lose up to $8 billion annually, according to USDA estimates. An outbreak of FMD, which is also easily introduced, highly contagious, and persistent-in the U.S. livestock industry could cost as much as $20 billion over 15 years in increased consumer costs, reduced livestock productivity, and restricted trade, according to the USDA.

The first major use of biological weapons in the 20th Century was Germany's attempt to infect Argentine, French, Mesopotanian, Romanian, and US livestock during World War I (Anthrax and glanders). France, Germany, and Japan are known to have developed more advanced agricultural weapons during World War II (Anthrax, glanders, fungi, nematodes, riderpest virus, hoof and mouth disease, potato beetles, turnip weevils, turnip bugs, antler moths, potato stalk rot, and potato tuber decay), and some experts feel the Soviet Union may have attempted similar attacks on German horses on the Eastern Front in World War II.

During the Cold War, the US weaponized and stockpiled wheat-stem rust, and weaponized rice blast fungus, rinderpest and foot and mouth disease (FMD). It carried out 31 anti-crop attack tests between 1951 and 1969, and stockpiled at least 5,000 kilograms of wheat and rice rust. The FSU weaponized and stockpiled FMD, rinderpest, African swine fever,

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vesicular stomatitis virus, contagious bovine pleuropneunomia, mutated avian influenza, contagious sheep ecthyma to attack animals, and wheat and barley mosaic streak viruses, potato virus, tobacco mosaic virus, brown grass virus, wheat fungal, and brown leaf rust. It also used radar to track the use of insect clouds. Iraq seriously examined ways to attack the Iranian grain crop and livestock (wheat rust and camelpox) during the Iran-Iraq War. Neither Germany nor Iraq carried out effective attacks, although in Iraq's case this may have been because it was not ready to attack until the Iran-Iraq war was over.[79]

Nature has already shown how easy it might be for a sophisticated, technically informed state, group, or individual to attack crops and livestock by introducing a new parasite, predator, or disease. There is no clear record of how many times such problems have occurred naturally in the US since World War II, but instances like the introduction of the Mediterranean Fruit Fly (which involved a group called the Breeders protesting the use of insecticides in California), cross breeding of "killer bees," poisoning of Chilean grapes, importation of mosquitoes with West Nile fever, and mere rumors that US apples might be covered in carcinogens are examples of cases involving millions of dollars. There are a host of "rusts" and "smuts" that can attack grain crops. Wheat rust, for example, can affect must of the Western and Great Plains wheat crop and some 12% of the California wheat crop was lost to this rust in one recent year. The following pathogens already threaten US crops as a result of natural causes: Soybean Rust (Soybean Plant), Ear Rot (Corn), Karnal Bunt (Wheat), Ergot (Sorghum), Bacterial Blight (Rice), Ring Rot (Potatoes) and Wirrega Blotch (Barley).

There is an even longer lists of threats to US livestock. They include Animal Disease Plant Disease, Foot and Mouth Disease, Vesicular Stomatitis, Rinderpest Gibberella, African Swine Fever, Highly Pathogenic Avian Influenza, Rift Valley Fever, Lumpy Skin Disease, Bluetongue, Sheep and Goat Pox, Swine Vesicular Disease, Contagious Bovine Pleuropneumonia, Newcastle Disease, African Horse Sickness, and Classical Swine Fever

Anthrax, Foot and Mouth Disease, Rinderpest, and Swine Fever are well researched ways to attack live stock.[80] In the case of "mad cow disease," less than 200 cases of sickness over

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more than 10 years caused billions of dollars. In contrast, foot and mouth disease is extremely contagious, has seven variants and 70 sub-variants, and airborne infections have been spread up to 150 kilometers by winds. Even single cases of foot and mouth disease have halted all exports of meat products from cloven-hoofed animals from some countries. The March 1997 outbreak of Foot and Mouth Disease in Taiwan forced the immediate destruction of 900,000 animals and an eventual total of up to 1.6 million, affecting exports which made up 41% of Japan's pork supply. The cost to the Taiwanese economy was one billion dollars a year. Alternatively, African Swine Fever is non-virulent against its natural hosts in Africa (ticks and warthogs), but is lethal enough against US pigs to act as the equivalent of a swine Ebola. [81]

The US Department of Defense has examined the possible impact of an attack using foot and mouth disease -- an agent that might be very difficult to distinguish from a natural outbreak and which could be manufactured and used by terrorist groups as well as by state actors – and has drawn the following conclusions: [82]

> The foot and mouth disease (FMD) virus is a member of the Picornovirus family, and the disease is endemic in many areas of the world. However, the United States has not dealt with the FMD virus since the 1920s. Therefore, few veterinary practitioners currently have the ability to recognize early stages of FMD infection. This agent is somewhat unique, as the animal becomes infective shortly after exposure and prior to the onset of clinical symptoms.
>
> To disseminate the agent, the mere transport of sloughed nasal vesicular tissue and modest preservation in transport could easily start an epidemic. For example, a single infected cow, or particularly a pig, can generate enough viral particles to infect vast geographical areas in a short period of time. FMD is characterized by a sudden rise in temperature, followed by an eruption of blisters in the mouth, nostrils, other areas of tender skin, and on the feet. The blisters grow larger and then break, exposing raw, eroded surfaces. Eating becomes difficult and painful, and because the soft tissues under the hoof are inflamed, the animal invariable becomes lame. Livestock raised for meat lose much weight, and dairy cattle and goats give far less milk.
>
> FMD usually kills very young animals and causes pregnant females to abort. The Animal and Plant Health Inspection Service (APHIS) of the U.S. Department of Agriculture (USDA) does not permit imports of FMD sero-positive animals. Considerable progress has been made toward developing an effective vaccine against FMD, but the cost (approximately $1 billion annually) of vaccinating all susceptible animals would be prohibitive. Moreover, the vaccine would not eradicate the disease. Consequently, the slaughter and incineration of all exposed animals is the only presently effective countermeasure to FMD. During an outbreak in the United Kingdom in 1967 and 1968, ore example, more than 430,000 animals were destroyed.

While agricultural and ecological attacks do not offer quick results or the kind of shock

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impact that can decide the outcome of short wars or achieve high immediate visibility, the other side of the coin is that they may also be extremely difficult to trace to any deliberate cause, have long-term effects that are very difficult to deal with and offer a potential means of revenge and punishment even to weak movements and states.

This risk explains why the Department of Agriculture has the mission of detecting and defending against such attacks. As is the case with human biological weapons, however, it is far from clear how genetic engineering will change the balance between defense and attack. Virtually all of the advances in biotechnology that can affect human diseases can be applied to the agents to attack crops and livestock and with far fewer risks in handling the materials and in weapons development.

The Problem of Response

Like chemical weapons, biological weapons *can* be a weapon of mass destruction with which most first responders and law enforcement agencies are able to deal. Attacks with limited medical effects can be dealt with as outbreaks of disease, and be contained and treated accordingly. Attacks on critical or sensitive facilities present more serious individual risks, but so do chemical attacks and bombs used against the same target. Similarly, false threats only need to be taken seriously to the point of ensuring that they do not produce mass panic.

Most responders feel -- probably correctly -- that they already have to prepare for such incidents, and the estimated total casualties from most limited or crude biological attacks of the kind that are unlikely to put an impossible burden on local and regional medical services. The law enforcement aspects, and forensics, of dealing with such biological attacks present challenges, but law enforcement experts believe most incidents will have a clear location and clear chains of evidence. This is more questionable in the case of attacks on livestock, crops, food, and the environment, but small, crude attacks of this kind also seem likely to be limited in effect and containable.

At the same time, there is the same broad consensus that there are still major problems in

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the rapid detection and characterization of even a limited biological and relatively crude biological attack, and in training and equipping suitable emergency medical personnel and facilities. These problems could be much more serious if a small and/or crude biological weapon **were** combined with an explosive or chemical device in attacking a building or facility, and/or responders had to characterize and deal with two sets of different biological weapons at the same time.

Funding Half-Measures and False Solutions?

The problems in responding to biological attacks radically change character, however, if they involve attack with enough agent to affect a large area, are conducted in a stealth or delayed mode, and/or involve attacks using highly lethal militarized agents. Such attacks could rapidly exhaust the response capabilities of any urban area or region. They could also involve weapons with very different methods of transmission, effects, and treatment requirements than a normal outbreak or epidemic.

Early response is critical in dealing with most attacks. It is unclear, however, that the US intelligence community is prepared to give warning of any kind against biological attacks. CIA Director George Tenet testified to the Senate Foreign Relations Committee on March 20, 2000 that biological warfare programs, "are becoming self-sufficient, challenging our detection and deterrence efforts, and limiting our interdiction capabilities…Biological and chemical weapons pose arguably the most daunting challenge for intelligence collectors and analysis." Tenet was referring largely to the threat posed by states, although he mentioned that a number of terrorist groups – such as Osama Bin Laden – were seeking to develop or acquire biological and chemical weapons.[83] Given the risk that US intelligence may not even detect the weaponization of biological agents, it seems almost certain that there is a much greater risk that any intelligence warning of a potential attack will not be able to name the agent(s) involved, and indicate the degree to which genetic engineering, the use of militarized strains, cocktails of mixes of different agents, and/or weaponization affect dissemination, lethality, and the effectiveness of the agent.

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Detection might well lag behind the deadlines for effective response and such attacks could infect or kill many local responders. Characterizing the risk of exposure and actual levels of exposure could prove to be a nightmare, as could separating out real exposures from feared exposures. It is unclear that anyone is prepared to determine the area covered by the agent (assuming it is non-infectious) and how many people were actually exposed and with what effect. The number of false reports, and people seeking cautionary or panic medical treatment would rise massively. The potential problem of halting movement, and establishing quarantines could overload law enforcement as well as create major lethal and ethnical issues. The fear of sequential or follow-on attacks would grow, and so would the problems in decontamination.

Advances have been made in detection and characterization at the military level. In October 1996, the Army fielded its first biological defense unit equipped with state-of-the-art biological detection capabilities, the Biological Integrated Detection System (BIDS). In 1999, a second unit was fielded with the BIDS Phase II Pre-Planned Program Improvement (P3I), which provided technology insertion from concurrent development efforts to upgrade the Phase I (4-agent detection capability) core configuration to 8-agent detection capability, automated detectors, and computerized integration of detection equipment outputs. In addition, the Army has fielded the Long Range Bio-logical Standoff Detection System (LR-BSDS), used for remote detection of aerosols and particulates. Also, the Interim Biological Agent Detector (IBAD) has been installed on selected Navy ships to provide a mobile biological point detection capability.

Department of Defense reporting does, however, provide a clear warning about the limits of current detection and characterization systems and technology, and in the research efforts to improve them. These limitations are severe even when the threat is confined largely to military operations against a relatively limited military target against fully alert forces in the field:[84]

> Because of the dual-use nature of BW technology, it is extremely difficult to prevent BW proliferation. No matter how good individual protective equipment and collective protective structures become, their utility is limited unless there is adequate warning to mask and seek cover. This fact places a premium on developing effective battlefield BW detection systems. Currently available equipment can be broadly divided between point detection/identification systems and standoff systems.
>
> Point detection and identification of biological agents in the field is done with vehicles and shelters containing manually operated, commercial off-the-shelf technology that use reagent processes, fluidics and

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spectrometry. Standoff systems, which can either be stationary or mounted on platforms like helicopters, rely on Light Detection and Ranging (LIDAR) technology to spot clouds of suspect particulate matter in the atmosphere from a distance. Both types of systems are capable of providing early warning, though point detection systems must be remotely deployed in an ensemble well upwind of friendly forces to be most effective.

The lack of sensitivity to low concentrations of biological aerosols and slow processing speed are the most critical shortcomings of our currently fielded point sensors. Since contamination can only be avoided with early warning, a sensor that reacts quickly to the earliest manifestation of a biological agent is the sine qua non of survival on the battlefield. Although an indication of the presence of agent can be provided very quickly by the Aerosol Particle Sizer (APS) component of the system, there is no way to tell whether the particles activating the trigger are harmful until the collection and identification functions are completed. This process takes from 15 to 45 minutes for high concentrations of agent. Low concentrations of agent require even longer detection cycles for the sensor systems. The extraordinary potency of these pathogens at even minute counts of agent containing particles per liter of air suggests that troops are very likely to be exposed to disease causing concentrations of them for some time before current point detection systems pro-vide the warning to mask. But, as the impracticality of detecting to warn makes detecting to treat look like a more probable outcome of responding to a biological attack, medical technology assumes ever more importance in the attempt to counter bio warfare.

The difficulty of relying only on established technologies or BW detection can be illustrated with an example. One recently proposed system involved distributing throughout the area of operations large numbers of point particle sensors linked to a sensor net-work command post — essentially a computer with algorithms to sort out the implications of alarms at different locations. An analysis of this system estimated that one false alarm per week per brigade with the allotted 24 sensors would result in the average divisional soldier being masked for 15 hours a week. To achieve this low a rate, already very disruptive to operational tempo, the system could allow no more than 0.006 false alarms per sensor per day — a standard not approached by contemporary capabilities. These concerns resulted in the elimination of the particle sensing units from the system.

While the rate of improvement in sensor performance against biological materials does not at present appear particularly promising, there are some grounds for encouragement due to the rapid and steady increase in the speed of information processing. It should, in theory, be possible to increase the efficiency of detection technology by linking networks of sensors. Digitized information networks, for a start, are faster than the analog networks they are replacing, and sensors incorporating some computing ability may eventually be able to pick out critically relevant returns rather than transmitting volumes of unprocessed data. The use of programmed algorithms to process returns in sensor network command posts has been pursued as a promising application of information processing technology to the detection and warning problem. This was the approach taken in the system discussed earlier that sought to link large numbers of particle sensors to a central unit. The hope was that this technology would permit the prediction of directional trends and speeds of agent clouds. But the potential for such systems is stunted by the stubborn limitations of the sensors themselves, and the likelihood that marginal improvements in them will be more than matched by substantial changes and improvements in the agents they are attempting to detect. Though the continual drama of advances in information technology seems to have given life to a generalized optimism about the prospects for across the board improvements in military technology, this case suggests that there are some defense problems not susceptible to the solutions offered by the information revolution.

The difficulties posed by the proliferation of biological weapons may demonstrate that, contrary to popular expectations, technical challenges do not of necessity generate increasingly ingenious technical responses in an unceasing reciprocal process. The likelihood that the detection problem will experience only gradual improvement means that some areas of technology, like information technology, may be limited in the contributions they can make to it, while others are made more important. The possibility that proliferating states may developing new agents such as modified viruses makes it desirable that the limited set of

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> classical agents available for presumptive identification with the current antibody-based identification technology be expanded. There are also gene-based systems in the inventory that use well-established polymerase chain reaction techniques to provide highly sensitive and specific identification of putative agents. These systems are two to three times slower than small, cheap handheld assays, and their size, weight, and power requirements have until recently been thought to render them impractical for the field. They have now been operationally deployed with encouraging results in Theater Army Medical Laboratories (TAML), where they can be operated and maintained by experienced technicians. Their identification technology is able to identify most classical agents within their incubation periods, except for the fast acting toxins. These latter agents are, in any case, more appropriately analyzed by more rapid immunoassay technologies such as the enzyme-linked immunosorbent assay (ELISA) or the even faster, more sensitive electro-chemiluminescence (ECL), both of which can be deployed with the TAML.
>
> … The need to have diagnostic tests directed at both endemic organisms and BW agents has become more apparent, since nonspecific symptoms of naturally occurring diseases (e.g., fever, fatigue, or respiratory complaints) may be identical to initial symptoms of biological agent infection. Technological advances have allowed for the development of rapid diagnostic tests for specific biological warfare agents, to include naturally occurring and bioengineered microbial organisms.
>
> Detectors that sample environmental organisms may not be sensitive or specific enough to identify "new" or emerging agents that have epidemic potential in a military or public health setting. In addition, with the advent of genetically manipulated variants, the need to have rapid and accurate means to determine antibiotic sensitivities, genomic sequences, and virulence factors, especially in bioengineered organisms, may become more important. Confirmatory evaluation at established reference laboratories within the United States requires a highly responsive system involving well-defined procedures in the collection, preparation, handling, and shipment of diagnostic specimens. The Theater Army Medical Laboratory (TAML) is a group of professionals who deploy before or with military units to survey and sample the environment and deter-mine the conditions. Samples are either evaluated by the deployed team in the field or packaged and shipped to reference laboratories for additional testing. DoD continues to identify appropriate technologies to bring the best tools to the warfighter through such institutions as the U.S. Army Medical Research Institute for Infectious Diseases (USAMRIID). Prototype systems are being developed and fielded at the installation and unit levels. The biological defense program aggressively pursues technology advances in standoff detection, remote early warning detection, sensor miniaturization, and improved agent identification sensitivity...

The Department of Defense reports that there are similar problems in trying to provide adequate treatment and medical services, although a number of research efforts are promising and stockpiling some vaccines may be of value. Once again, however, its conclusions apply to dealing with military forces, and not the much larger potential target base in the US homeland.[85]

> There are serious but not insurmountable organizational and medical obstacles to the success of post-exposure treatment. The number of known bioagents to which U.S. personnel in either Southwest Asia (SWA) and Northeast Asia (NEA) are considered most likely to be exposed is at least as high as ten. The daunting logistical prospect of procuring vaccines, prophylaxes, and other treatments for all these agents suggests, at first glance, that the availability of appropriate medical countermeasures is the first and principal limiting factor on the post-exposure strategy; and, of course, the medicines must be supplied in the right place and at the right moment to all personnel who might have been exposed. But the applicability of certain treatments to multiple diseases (doxycycline, for instance, can be used against plague, tularemia, anthrax, brucellosis, and Q-fever) would lighten the logistical burden.

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The research being done to develop polyvalent or multidisease resistant vaccines could eventually make a valuable contribution to our medical countermeasures, particularly in meeting the unpredictable threat of modified viruses. But this would only be the case if scientists succeed in creating vaccines that could actually short circuit the pathogenic mechanisms common to all agents. A limited number of conventional, single-disease vaccines (anthrax, smallpox, plague, and botulinum) should be adequate to protect U.S. forces against most biological weapons currently suitable for large-scale operational use. Though this would establish a major element of force protection, the engineering of novel viruses for military use could be a matter for increasing concern in the future.

…Medical prophylaxes, pretreatments, and therapies are necessary to protect personnel from the toxic or lethal effects of exposure to all validated threat agents, as well as other potential threats. DoD has fielded a number of medical countermeasures that greatly improve individual protection, treatment, and diagnoses. Vaccines are the most effective and least costly protection from biological agents. There has been significant progress within the area of biological defense vaccine policy and development. The Department has established policy, responsibilities, and procedures for stockpiling biological agent vaccines and determined which personnel should be immunized and when the vaccine should be administered. DoD also has identified biological agents that constitute critical threats and determined the amount of vaccine that should be stocked for each threat. Other preventive and therapeutic measures, such as broad-spectrum antibiotics, may be used for treatment following a biological attack with bacterial agent.

… Anthrax is a biological warfare agent that has been produced and weaponized by adversaries of the United States. A small amount of anthrax spores, distributed under proper conditions, can generate a large number of fatalities among individuals who are not properly protected. While protective clothing and gas masks provide excellent front-line defense against anthrax and other biological agents, their effective use requires rapid and early detection of the agent. Current detection devices may not provide enough time for personnel to don protective equipment before exposure. Ideally, the United States should be able to deter the use of anthrax. As Secretary of Defense William Cohen warned in 1998, if any state "even contemplates using WMD against our forces, we will deliver a response that's overwhelming and devastating." In the event deterrence fails, however, an added level of protection must be provided to our forces. For protection against anthrax, there is a safe and effective vaccine licensed by the Food and Drug Administration (FDA).

…Medical countermeasures for biological threat agents are limited but improving. A Joint Medical Biological Defense Research Program is developing countermeasures to protect U.S. forces and thereby deter, con-strain, and defeat the use of biological agents. A primary objective is the development of vaccines, drug therapies, diagnostic tools, and other medical products that are effective against biological agents. Efforts are focused on maintaining the technological capability to meet present requirements and counter future threats, providing individual-level prevention and protection and providing training in medical management of bio-logical casualties. A research program directed at the development of safe and effective antiviral drugs is also in progress. Current medical biological defense program research involves pre- and post-exposure BW countermeasures as well as diagnostics, including the following:

- Characterize the biochemistry, molecular biology, physiology, and physical structure of BW threat agents.
- Investigate the disease mechanisms and natural body defenses against BW agents.
- Determine the mechanism of action of these threat agents in animal model systems.
- Develop and compare potential vaccine candidates and characterize their effects in animal models.

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- Establish safety and efficacy data for candidate
- Vaccines. Develop medical diagnostics to include field confirmatory and reference laboratory techniques. Develop effective casualty treatment protocols using antitoxins, antibiotics, antivirals, and other pharmaceuticals to prevent death and maximize return to duty.

> …Research, Development, Test, and Evaluation (RDT&E) efforts are underway to develop vaccines against all validated threat agents, including plague, smallpox, and tularemia, although it will take a number of years to successfully complete all of these vaccines….There are a number of medical biological defense products transitioning to advanced development and in varying stages of review for licensure by the FDA. These include vaccines for botulinum and Venezuelan Equine Encephalitis (VEE), plague, brucella, Marburg (filovirus) and a common diagnostic system for rapid biological agent identification and agent prophylaxis.

The current weapons effects literature simply cannot prepare defenders and responders for what would really happen if large amounts of given agents were broadly disseminated, or highly infectious military agents were used. No currently deployed detection system can accurately measure the area coverage of such an attack, and most projected detection systems – including most biochips -- would present problems in reliably characterizing the exact weapon used and/or the amount of the weapon present in given areas, and the degree to which it does or does not mimic all of the patterns of a normal disease. While more sophisticated individual detection and characterization devices are becoming available, and much more reliable and advanced systems are completing development, there as yet are no rapidly deployable arrays that can be used in urban environments, and must responders have no funds to acquire them. In fact, the NSC was just beginning to examine the kinds of "systems" that might be required in August 2000.

The resulting response problems will be greatly complicated by the steady decline in public health funding and in the number of hospitals and emergency facilities per patient that has affected the US and virtually every nation in the West. The US saw over 1,000 hospitals close in the 1990s, medical services shift to minimize stocks and any kind of surplus capacity, and many emergency wards close. In the late 1990s, nearly 30% of America's remaining hospitals were losing money. The US Public Health Service, and state and local public health departments, have been badly underfunded and the overall system can barely cope with its normal caseload.[86]

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No hospital in the country can deal with more than 50-100 patients requiring isolation. It can also take a critical 24-48 hours to move federal and state resources to a local facility once (and if) an attack is detected, and hospitals are not funded to do anything to bridge the gap. Furthermore, it is far from clear that detection of some kind of bioattack is any guarantee that such an attack can be characterized in a sufficiently precise way to allow hospitals/caregivers, and local, state, and federal authorities to know what kind of services and treatment to provide and what kind of aid to ask for.[87]

The end result could easily be to funnel patients into a public health system and hospital network with almost no surplus capability, which had neither the facilities nor the stockpiles to treat the result of a biological attack, and which would be incapable of rapidly diagnosing the exact nature of an attack. While similar problems would occur in responding to any major CBRN attack, biological attacks ultimately place a critical response burden on hospitals and advanced medical facilities. The creation of federal groups like the Office of Emergency Preparedness in HHS and the Bioterrorism Preparedness and Response Office of the Center for Disease Control, and training of state and local health departments, training of military and National Guard personnel are all useful measures. So is the creation of the 7,000 volunteer force in 30-person Disaster Medical Assistance Teams, although few members of the teams are doctors. No system can work, however, that then cannot treat the patient load, and the burden of treatment/isolation/quarantine would be far greater in the case of an infectious attack, particularly one that was only detected after it had spread.

Current plans to stockpile vaccines and given types of treatment aids seem to assume that attacks will be limited and will not involve militarized or highly effective agents or mixes of agents that cannot be detected and/or treated as regular diseases. This may well be valid, but it is unclear that the classified work done by the military services, DTRA, and CDC in looking at the full range of biological agents have yet been translated into anything approaching reliable effects models, and that planning which is not familiar with the full range of militarized agents and military risks is always valid for more than limited and unsophisticated attacks. They also tacitly

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assume that attacks can be detected and characterized in time to react and that vaccines can be moved to effective public health authorities who can discriminate who should be vaccinated and carry out the actual vaccination in time to be effective.

Biotechnology may well give the "defense" as many advantages, or more, than the "offense." However, anyone can promise the biological equivalent of the philosopher's stone and universal solvent and some programs seem to be very poorly justified and grossly oversold. Many of the stockpiling, vaccine, and research and development programs underway do not seem to have been supported by any kind of net technical assessment of the cost to defeat them, the advances taking place in possible attack technologies, and what the cost of national deployment would really be. Many RDT&E programs are being oversold and over-hyped in what seem to be dangerously over-simplistic terms. In many cases, no effort is made to describe their probable deployment and life-cycle costs or even what actual deployment would entail.

The Need for Constantly Updated Net Technical Assessments

These problems are compounded by what seems to be the lack of any clear net assessment of the probable trends in the offensive and defensive capabilities of biotechnology. Some programs hype the problem and some hype the solution. Many assume that a solution that works with current biotechnology will be valid five, ten, or more years in the future, and that sophisticated attackers will not choose new means of attack even though they have years of public warning of the measures the US plans to take to reduce its vulnerability. These problems are made worse by a flood of policy and strategic studies literature with no supporting references to technology.

The unclassified literature is filled with unsubstantiated and poorly referenced assertions, and efforts to sell given programs. The gap between "science" based on normal patterns of disease and the different risks posed by militarized agents is brutally and almost constantly apparent. It is true that no one net technical assessment can hope to accurately predict the future, but the need for well funded assessments that have both classified and unclassified versions is

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painfully clear.

These problems are compounded by a failure to integrate suggested response and RDT&E efforts for biological attacks into a realistic overall set of procedures that take account of day-to-day public heath needs, real-word pressures to reduce the cost and level of medical services, and the impact of dealing with the aging of the American population. Biological warfare planners and responders sometimes seem to assume that they have an axiomatic priority for resources. They plainly do not.

Reconsidering the Practical Problems in Defense and Response

The threat posed by biological weapons illustrates the need to be able to measure the existing capabilities of federal, state, and local defenders and responders, to determine what can be done to improve their capabilities with minimal or no additional resources, and then to expressly address what level of additional capability the nation is and is not willing to fund. At present, federal efforts are just beginning to develop a detailed picture of existing national capabilities, and much of the governmental effort at every effort is concerned with basic efforts to understand the problem, coordinate, and train. There is no question that this effort is producing progress, but it does not create a system or architecture for Homeland defense, and no one has seriously addressed the question of "how much is enough?"

Biological weapons offer an extraordinarily wide spectrum of means of attack with highly unpredictable effects and lethality. They can vary from limited use of toxins by individuals up to extremely lethal attacks by state actors. It also seems prudent to assume that biological weapons present a serious potential threat in spite of the lack of any past history of effective use, and the problems in manufacturing, handling, and delivering them. Homeland defense requires the US to consider the following factors:[88]

- The psychological and political impact of using such weapons can be varied according to the means of attack. Weapons can be designed to kill or incapacitate, or to attack livestock, plants, and specific foods.
- The amounts of biological weapons needed to achieve a given effect are usually far smaller than for conventional or chemical weapons. Some are easy to smuggle and safe to handle by personnel who have

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had suitable medical treatment.

- Some biological weapons are so lethal, they potentially approach the lethality of nuclear weapons.
- While the technical skills involved in making such agents are high, biological weapons can be relatively easy to manufacture if such skills are present, and such skills and the required equipment are becoming increasingly common.
- Biological weapons are hard to detect and characterize, particularly if more than one type of weapon is used, or the nation is not on the alert.
- Defense is difficult at best. Effective vaccines and treatment are often not available, or must be administered very quickly. Casualties often require intensive and long-term care and therapy, possibly saturating available care.
- The impact of an attack can be timed in ways that favor the attacker. The time before the effects of an attack varies. It may be hours, days, or weeks before an attack is apparent, and this could severely restrict warning, detection, and the value of treatment.
- The US would find it extremely difficult to estimate the seriousness of the attack and react accordingly. It is difficult to characterize the scale of the threat and its impact until symptoms appear and the casualties can be judged by the number of sick or poisoned.
- Unprotected medical and emergency personnel are highly vulnerable if they enter areas they do not know have been attacked, or attempt treatment when no cure is available.

It is not clear that anyone can assign valid probabilities to the kinds of biological attacks that will be made on the American homeland. It is also clear that the frequency of given types of attacks is not a meaningful criterion. There already is a flood of false Anthrax threats and attacks, and the frequent efforts by extremists and disturbed individuals to use chemical and biological weapons on a small scale are almost certain to continue. Some attacks will almost certainly eventually succeed. In fact, some attacks on food and agricultural products have already succeeded.

The Problem of Large-Scale or Highly Efficient Attacks

The key risk is the kind of highly lethal attack that would involve more sophisticated weapons. The US cannot afford to ignore the fact that a single, well-executed covert attack by a state actor or proxy could produce casualties on the order of tens of thousands – easily resulting in more cumulative casualties than hundreds of small attacks. It could also involve far more stable agents that would survive exposure to heat and light, and involve strains or generic

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manipulation to reduce or eliminate the effect of conventional medical treatment. There also are no rules preventing multiple attacks and/or the use of multiple biological weapons at the same time, and attacks that hit medical and response capabilities as well as civilians.

The lead times involved in developing an effective deterrent and defense present another critical issue. Advances in biotechnology and food processing, and the proliferation of these technologies and related delivery and weaponization technology, are steadily increasing the ease with which nations and terrorist/extremist groups can acquire the means to make biological weapons. The use of "dry" storage biological weapons is likely to become widespread over the next 5-10 years, and the necessary skills may become available. Genetic engineering is introducing a whole new set of risks to the equation.

The lack of clear lethality and effects data also has major implications for Homeland defense:

- It may not be possible to detect and characterize a biological attack (or attacks) until it is too late to provide effective treatment, to determine what levels of medical resources are required, or know how many response and treatment capabilities have been attacked and what level of patient flow will result. Much of the current response planning tacitly assumes that either incidents will be small and familiar enough to allow existing response capabilities to work or that attacks will be detected and characterized in ways that allow effective response planning for reasons that are not clearly explained.

- Much of the response planning assumes that it is possible to predict the required medical treatment based on limited experience with civil incidents and epidemics. It is not clear that the “scaling” involved in estimating the effect of terrorist, extremist or covert use of more sophisticated weapons is more than speculative, and many studies do not cite the special evidence and method used to scale up civil cases into estimates of how biological weapons would behave.

- The uncertainty created by the ability to modify or engineer new weapons or forms of existing weapons greatly compounds these problems. There do not seem to be net assessments of the balance between changes in offensive and defensive biotechnology that allow the US to predict future lethalities or the effectiveness of many proposed response measures.

- Most of the measures the US takes to provide Homeland defense against biological weapons immediately become part of the open literature, and many take years of lead-time to become effective. While this can act as a deterrent, it can also act as a road map for states and sophisticated extremists in finding the weaknesses in US defenses. The ability to select or tailor biological weapons that remain lethal in spite of US efforts at defense has had only limited analysis.

- There are a number of detailed problems in detection, characteristics, and effects analysis. For example, reliable models of biological weapons effects do not seem to exist which cover attacks in major

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urban areas involving massive complexes of high rise steel and glass buildings. The containment and transmission effects of modern cities are extremely difficult to model.

- Most effects estimates only apply to the use of one biological weapon, but attacks using "cocktails" of several biological weapons were found to be the most effective method of mass attack during the Cold War.

- There is often a gap between generic data on the treatment needed for a given biological weapon and the assumed level of treatment required. There is the tacit or explicit assumption that a weapon can be treated as a conventional disease, and that enough will be known about effects and exposure for treatment to be applied.

- Much of the federal, state, and local response literature effectively dodges around the issue of triage, and the problem of choosing who will receive limited medical treatment and how these victims will be selected. It does not describe what is done with the assumed dying and untreatable or to contain those who may transmit diseases. It also does not address the issue of how hospitals and care givers can determine what level of resources are needed for those who can be treated – a critical issue given the limited specialized medical facilities in most areas in the US.

- Corpse disposal may be a major problem, as may disposal of dead animals and birds. This aspect of response seems to be largely ignored.

- Even military medical handbooks fail to address the psychological impacts of prompt and longer-term effects.

One key problem in dealing with all of these issues and options is that defense and response must general begin at the local level, and state and federal aid will come hours or days after the event. In the case of both advanced biological and nuclear attacks, however, local law enforcement, emergency services, and medical services are likely to collapse relatively quickly. Regional and federal law enforcement, defenders, and responders will have to bear the brunt of trying to stop or contain an incident if there is warning and ameliorate the consequences if it succeeds. Unlike chemical attacks, local and regional capabilities will not be the decisive factors for determining the outcome of limited and unsophisticated biological attacks and high explosive attacks. Regional and federal resources must brought to bear in as little time as possible.

This, however, raises the question of what overall resources are needed, and what federal role is needed to provide them. So far, this question has tended to be answered more in terms of counterterrorism than response, and emergency response capabilities are better trained and organized than medical services. There are serious variations in response capability by town and region, and it is not clear what standards need to be set for each urban area, or to deal with

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attacks on critical facilities in areas which lack the resources approaching those of major cities.

It is obvious from the testimony and briefings of both responders and medical professionals that public health has been steadily downsized in ways which limit the ability to handle the high patient loads from biological and nuclear attacks. These problems seem likely to grow steadily more serious as more public resources are shifted to dealing with the aging, and are compounded by a search for cost-effectiveness among medical professionals. This again illustrates the fact that effective Homeland defense cannot be separated from national health policy and the overall problems in balancing out treatment cost, the need to provide continuing peacetime services, and changing priorities to meet an aging population and deal with welfare reform. At present**,** cost and capacity constraints are so severe that medical facilities often cannot participate effectively in exercises and training for Homeland defense.

Other Problems in the Present Response Effort

The briefings of responders and law enforcement officials raise other problems that affect biological attacks and other large-scale CBRN attacks in ways that may seriously limit the adequacy of present federal, state, and local efforts to deal with the problem:

- Large-scale biological attacks highlight the conflict between the normal civil rights considerations affecting interference with civil liberties, the law enforcement priorities necessary to obtain evidence and convictions, and the need to take every possible measure to prevent follow-on attacks, the need **to** provide immediate emergency services, and long-standing problems in using US intelligence assets to support defense and response inside US territory when it may involve US citizens.

- Intelligence warning of the exact nature of a probable biological attack can be absolutely critical to effective response – although it may be difficult or impossible. The ability to identify the specific disease that may be used in attacks would greatly simplify detection and treatment. So would warning of the potential difference between relatively unsophisticated attacks using familiar diseases and toxins and more sophisticated attacks using dry micropowders, unfamiliar agents, strains bred to resist treatment or decay, or genetically engineered disease. In many cases, effective response may be impossible without such warning.

- There is a need to provide some kind of cost-effective detection and characterization system that can be rapidly deployed before or after an attack, and which will provide an accurate picture of how much of what agent is present in what area. Models lack the accuracy to substitute for measurement. At present, more effort seems to be going into improving individual detectors than in to creating deployable and affordable systems that can be available for local use – a problem compounded by the need to provide biological and nuclear detection and characterization as well as chemical. This kind of real time information is critical not only to first responders, but to the efficient use and allocation of law enforcement and intelligence

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resources in defense and regional, state, and federal aid in response.

- No one really seems to want to confront the issue of triage, and of deciding who gets treatment, who is left at risk, and who dies. This simply is not a realistic approach. Triage cannot be improvised by practitioners without a major risk of wasting inadequate resources on the moving dead and leaving the curable untreated. Creating systems to decide what level of risk is involved in urging people to stay put or evacuate, how to control the media, and what level of detail to provide should not be left up to responders in a crisis. Such planning can only be done at a federal level, but it is uncertain that the leadership and moral courage is present to do it.

Dealing with the psychological and political impacts of biological weapons present additional problems. While most urban responders have at least token plans for handling the public relations aspects of biological accidents, it is far from clear that these plans would work in dealing with major attacks or sequential attacks. It is again clear that national and local media are not prepared to report on such attacks, and to perform a civil defense role. The psychological dimension also presents problems because it is not clear that the normal decontamination of areas, facilities, and buildings will not leave trace problems or that the public can be convincingly reassured of what is and is not safe. More broadly, the long-term medical effects of a large-scale attack are very difficult to characterize, and the Gulf War has shown how the resulting uncertainties can create major medical, psychological, and political problems.

Cost-Effectiveness of Real-World Options

There are options for improving US defense and response capabilities to biological attacks, some of which the government is already aggressively exploring and many of which apply to all forms of major CBRN attacks. The existing federal effort is discussed in depth in the following sections of this analysis, which discuss the present size and nature of the federal effort by department and agency. At the same time, it is clear that the following options and issues need continuing examination – particularly in the light of the cumulative long-term risk of major biological (and nuclear) attacks:

- The role of intelligence in defense and response needs to be addressed to determine the probable ability to detect the development of biological weapons, the specific agents under development, the strain, and the nature of the delivery systems. The need to communicate warning to responders and treatment facilities as well as defenders needs to be addressed.

- Zero-based investigation is needed of the probable effects and lethality of biological weapons which

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examines the use of both normal diseases and militarized strains. This should specifically include the issue of weaponization and the effect of different levels of efficiency in weaponization.

- Specialized intelligence and defense capabilities must be developed for warning, detection, characterization, and defense. This is not only a task for the national intelligence, security, and law-enforcement community, but also for federal, state, and local law enforcement and state National Guard units. The problem of finding cost-effective mixes of specialized CBRN expertise, and linking these efforts to response activities will present a constant challenge in terms of law, resources, organization, and training.

- As part of the development of intelligence, defense, and response capabilities, explicit analysis is needed of the trade-offs between the risk posed by mass attack and the separation of foreign intelligence from law enforcement, and the priority given to prosecution versus defense. The scale of the treat and the needed response times call for almost total integration of the intelligence, defense, and response effort, but this now presents major legal and organizational problems.

- The ability to convincingly identify attackers needs to be determined, as well as the possible timelines, as part of an effort to create a credible threat of retaliation and punishment at the military and law-enforcement levels.

- A major research and development effort is already underway to improve detectors. The role that new technical aids like strain analysis, VNTR analysis, localization, phylogentics, DNA tags, pathogen isotopes – needs to be addressed as part of an effort to determine what can be done to improve warning, detection, characterization, response, and treatment.

- The CDC and DTRA evidently are already examining models that are capable of providing a more realistic picture of the effects of biological weapons in urbanized environments and how they might behave in real-world attacks. These seem to include the use of modern militarized agents. Virtually the same need exists to improve the modeling **of** all forms of CBRN attack.

- As part of this effort, the need to be able to model and predict the effect of the atmospheric boundary level, and estimate the combined impact of air movements, temperature, and day-night conditions in an urbanized environment is critical to predicting effects and the capability for detection. The need for models capable of reflecting local wind and weather conditions, and water flows is equally important. Nominal models of plumes and weather effects are now so uncertain that they may do more harm than good in providing guidance for detection and response.

- Zero-based investigation is needed of how to link the detection and characterization of biological agents to a system capable of measuring the scale and lethality of attacks. Efforts to develop advanced real time detectors need to be tied to a clear plan for deployment as a system – including fixed versus mobile sensor arrays and the possible use of municipal vehicles as sensor platforms. This should include the ability to provide the data needed to identify the need for containment, isolation, treatment, disposal, and decontamination. This examination must address fundamental cost-effectiveness issues as to whether systems can or should be deployed without strategic and tactical warning, and can be rapidly deployed and should consider the real-world problems of developing such systems to deal with infectious disease and their epidemiology.

- The problem of providing integrated detection and characterization of all forms of CBRN attack must be addressed at the same time, along with its cost-effectiveness. The limits of such systems, their level of accuracy and error, and their ability to reliably address the scale and area of coverage of attacks

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must be addressed .

- The potential role of any such a detection and characterization system must be examined in a broader context. Methods of transmitting data to defenders, responders, and caregivers – including hospitals and public health facilities need to be identified. As part of such systems, a clear linkage needs to be established between local detection and characterization and communication of the results to state, regional, and federal authorities. Methods need to be developed to use the results to immediately alert caregivers and local, state, and federal authorities to assemble the necessary containment and treatment resources. Contingency plans need to be developed to use the media to alert those in and near the affected area as to what to do in the presence of a given agent(s).

- Current efforts to develop detectors need to be recalibrated to consider the problems of telemetry and triage – including presymptomatic triage.

- The cost-effectiveness of vaccine stockpiling needs careful examination. Focusing on Anthrax and smallpox may be a valid option. It may also drive attackers to choose other diseases or develop strains/genetically engineered variants that are immune. The option of "silver bullet" antibiotics and vaccines capable of dealing with a wide range of existing diseases, militarized strains, and genetically modified diseases needs full net technical assessment.

- The cost-effectiveness of enhancing local public health capability needs examination as does the overall cost-effectiveness of developing suitable response local government systems. It is easy to call for federal support, and HHS/FEMA training and aid efforts. The tangible benefits per dollar in terms of lasting capabilities to deal with attacks are far from clear.

- Adding courses on biodefense to current medical and post-graduate training may be cost-effective.

- The hospital seems to be the current weak link in most serious bioattacks. The cost-effectiveness of federal programs, regulations, and tax credits in creating hospitals with improved CBRN and biodefense and treatment capabilities needs serious examination. At present, far too much of the defense/response effort would simply end in overloading existing medical treatment facilities.

- Efforts are already underway to create specialized National Guard and reserve CBRN defense units. The capability to contain, isolate, perform triage, and treat seems to be the critical current weak link in such efforts, and is compounded by the lack of well-funded public-health programs capable of organizing and training reserves of local caregivers.

- Civil defense options need to be reexamined in terms of building design and modification, personal defense equipment, and possible home protection and care options. These need to be examined in terms of their real world cost-effectiveness, and value in dealing with the full spectrum of CBRN attacks.

- A comprehensive plan is needed for dealing with local, state, and national media. This must involve education efforts, voluntary agreement to provide coverage that will inform without creating panic or misinformation, and some effort to provide clearly official coverage that viewers and listeners will trust. Consideration is needed of bringing back some form of authorized civil defense network in the effect of large-scale nuclear and biological attacks.

- Much of the current planning effort sees one major attack with one agent used in a form that federal, state, and local authorities clearly detect and characterize as the "worst case." Defense and response needs to examine cases involving multiple attacks, deception and false alarms, false characterization,

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and late detection. The problem of dealing with contagious disease outbreaks that are only detected after they have reached at least scatter regional or national levels is particularly important.

- The nation needs to be prepared for the "morning after." A clear plan is needed for Presidential response and national leadership in the event of a successful attack, and to prepare the American people for both follow-on attacks and the need for a US response.

- The issue of retaliation and counter-offensive options in the event of foreign attacks must be transformed into credible options that can be communicated in ways that reassure out allies, create a clear context for American counter-attacks that the world will understand, and which deter attackers.

The problem with this list is obvious, particularly when considered in the light of the need for federal response to existing public health care and entitlements needs, the existence of the full spectrum of CBRN attacks, the addition risks posed by missile and critical infrastructure attacks, and existing national security requirements. The checklist of necessary options is *very* long, the short-term risks are low, the effectiveness of most options is uncertain, and the cumulative cost is high. Furthermore, it is not possible to prioritize defense and response at this point in time, and the effectiveness of any program may be determined by its weakest and/or most expensive link. Anyone can call for action. Developing an affordable and well-justified program is an entirely different matter.

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Table 4.5

Biological Weapons: Known Development of Agents by the Major Powers Before the BWC

Agent	Canada	France	Germany	Japan	UK	USA	Russia
Bacteria							
Anthrax	+	+	+	+	+	+	+
Brucella		+				+	+
Chlamydia psittaci					+		
Dysenteria		+		+	+	+	+
Gas gangrene		+		+			
Leprosy				+			+
Tuberculosis							+
Pseudomonas mallei		+	+	+		+	+
Pseudomonas Pseudomallei		+		+		+	
Tetanus		+		+	+		+
Typhoid		+		+	+		+
Typhus		+		+	+		
Vibro Cholera			+	+	+		+
Yersinia Pestis			+	+	+		+
Viruses							
Eboloa		+			+	+	+
Encephalitis		+				+	+
FMD			+				+
Fowl plague		+				+	
Influenza		+		+		+	+
Newcastle disease							
Rinderpest	+	+	+			+	
Korean haemorrhagic Fever				+			
Toxins							
Botulin	+	+		+	+	+	+
Ricin		+		+	+	+	+
Saxitoxin						+	+
Staphylococcus						+	+
Enterotoxin B					+		
Snake Toxins				+			
Tetrodotoxin (fish poison)				+			
Arthropods							
Potato beetles		+	+				
Fungi							
Coccidioides immitis						+	
Other							
Malaria				+			
Weeds			+				
Phytopathogens						+	+
Fish pathogens							+

Source: SIPRI and IDA

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Table 4.6

US Department of Defense Estimate of Potential National Threats Intentions Involving Biological Weapons

China

China continues to maintain some elements of an offensive biological warfare program it is believed to have started in the 1950s. China possesses a sufficiently advanced biotechnology infrastructure to allow it to develop and produce biological agents. Its munitions industry is sufficient to allow it to weaponize any such agents, and it has a variety of delivery means that could be used for biological agent delivery. China is believed to possess an offensive biological warfare capability based on technology developed prior to its accession to the BWC in 1984. China actively participates in international efforts to negotiate a BWC compliance protocol.

Since 1984, China consistently has claimed that it never researched, produced, or possessed any biological weapons and never would do so. Nevertheless, China's declarations under the voluntary BWC declarations for confidence building purposes are believed to be inaccurate and incomplete, and there are some reports that China may retain elements of its biological warfare program.

India

India has many well-qualified scientists, numerous biological and pharmaceutical production facilities, and biocontainment facilities suitable for research and development of dangerous pathogens. At least some of these facilities are being used to support research and development for biological warfare defense work. India has ratified the BWC.

Iran

Iran has a growing biotechnology industry, significant pharmaceutical experience and the overall infrastructure to support its biological warfare program. Tehran has expanded its efforts to seek considerable dual-use biotechnical materials and expertise from entities in Russia and elsewhere, ostensibly for civilian reasons. Outside assistance is important for Iran, and it is also difficult to prevent because of the dual-use nature of the materials and equipment being sought by Iran and the many legitimate end uses for these items.

Iran's biological warfare program began during the Iran-Iraq war. Iran is believed to be pursuing offensive biological warfare capabilities and its effort may have evolved beyond agent research and development to the capability to produce small quantities of agent. Iran has ratified the BWC.

Iraq

Iraq's continued refusal to disclose fully the extent of its biological program suggests that Baghdad retains a biological warfare capability, despite its membership in the BWC. After four and one-half years of claiming that it had conducted only "defensive research" on biological weapons Iraq declared reluctantly, in 1995, that it had produced approximately 30,000 liters of bulk biological agents and/or filled munitions. Iraq admitted that it produced anthrax, botulinum toxins and aflatoxins and that it prepared biological agent-filled munitions, including missile warheads and aerial bombs. However, UNSCOM believed that Iraq had produced substantially greater amounts than it has admitted –three to four times greater.

Iraq also admitted that, during the Persian Gulf War, it had deployed biological agent-filled munitions to air-fields and that these weapons were intended for use against Israel and coalition forces in Saudi Arabia. Iraq stated that it destroyed all of these agents and munitions in 1991, but it has provided insufficient credible evidence to support this claim.

The UN believes that Baghdad has the ability to reconstitute its biological warfare capabilities within a few weeks or months, and, in the absence of UNSCOM inspections and monitoring during 1999 and 2000, we are concerned that Baghdad again may have produced some biological warfare agents.

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Libya

Libya has ratified the BWC, but has continued a biological warfare program. This program has not advanced beyond the research and development stage, although it may be capable of producing small quantities of biological agent. Libya's program has been hindered by the country's poor scientific and technological base, equipment shortages, and a lack of skilled personnel, as well as by UN sanctions in place from 1992 to 1999. Without foreign assistance and technical expertise to help Libya use available dual-use materials, the Libyan biological warfare program is not likely to make significant progress beyond its current stage. On the other hand, with the suspension of UN sanctions, Libya's ability to acquire biological-related equipment and expertise will increase.

North Korea

North Korea has acceded to the Biological and Toxin Weapons Convention (BWC), but nonetheless has pursued biological warfare capabilities since the 1960s.Pyongyang's resources include a rudimentary (by Western standards) biotechnical infrastructure that could support the production of infectious biological warfare agents and toxins such as anthrax, cholera, and plague. North Korea is believed to possess a munitions-production infrastructure that would allow it to weaponize biological warfare agents and may have biological weapons available for use.

Pakistan

Pakistan is believed to have the resources and capabilities to support a limited biological warfare research and development effort. Pakistan may continue to seek foreign equipment and technology to expand its bio-technical infrastructure. Pakistan has ratified the BWC and actively participates in compliance protocol negotiations for the treaty.

Russia

The FSU offensive biological program was the world's largest and consisted of both military facilities and civilian research and development institutes. According to Ken Alibek, the former Deputy Director of BIO-PREPARAT, the principal Soviet government agency for biological weapons research and development, by the early 1970s, the Soviet Union had developed a biological warfare employment doctrine, where biological weapons were categorized as strategic or operational. Alibek stated that they were not to be employed as tactical weapons. Strategic biological agents, those to be used on "deep targets," such as the continental United States, were the lethal variety and included smallpox, anthrax, and plague. Operational agents, those intended for use on medium-range tar-gets, but well behind the battlefront, were the incapacitating variety and included tularemia, glanders, and Venezuelan equine encephalitis.

For both strategic and operational employment, the Soviet goal was to create large numbers of casualties and extensive disruption of vital civilian and military activities. The Former Soviet Biological Warfare Program was a massive program involving tens of thousands of personnel. Thousands of tons of agent reportedly produced annually, including anthrax, smallpox, plague, tularemia, glanders, and Venezuelan equine encephalitis. Perceived for strategic use against targets in the United States. Dual-use nature of virtually all materials involved in production process makes it difficult to determine conclusively the exact size and scope of the former Soviet program, or any remaining effort

The former Deputy Director further stated that although the Soviet Union became a signatory to the 1972 BWC, it continued a massive program to develop and manufacture biological weapons. Alibek claims that in the late-1980s and early-1990s, over 60,000 people were involved in the research, development, and production of biological weapons in the Soviet Union. The annual production capacity of all of the facilities involved was several thousand tons of various agents.

The Russian government has publicly committed to ending the former Soviet biological weapons program and claims to have ended the program in 1992. Nevertheless, serious concerns remain about Russia's offensive biological warfare capabilities and the status of some elements of the offensive biological warfare capability inherited from the FSU. Since the breakup of the Soviet Union, more extensive downsizing and restructuring of the program have taken place. Many of the key research and production facilities have taken severe cuts in funding and personnel. However, some key components of the former Soviet program may remain largely intact and may support a possible future mobilization capability for the production of biological agents and delivery systems. Despite Russian ratification of the BWC, work outside the scope of legitimate biological defense activity may be occurring now at selected facilities within Russia, and the United States continues to receive unconfirmed reports of some

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ongoing offensive biological warfare activities.

Syria

Syria has signed but not ratified the BWC but nonetheless is pursuing the development of biological weapons. Syria's biotechnical infrastructure is capable of supporting limited agent development. However, the Syrians are not believed to have begun any major effort to put biological agents into weapons. Without significant foreign assistance, it is unlikely that Syria could manufacture significant amounts of biological weapons for several years.

Source: Adapted by Anthony H. Cordesman from Department of Defense, Proliferation and Response, January 2001

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Table 4.7

Key Biological Weapons - Part One

Disease	Infectivity	Transmissibility	Incubation Period	Mortality	Therapy
Viral					
Chikungunya fever	high?	none	2-6 days	very low (-1%)	none
Dengue fever	high	none	5-2 days	very low (-1%)	none
Eastern equine encephalitis	high	none	5-10 days	high (+60%)	developmental
Tick borne encephalitis	high	none	1-2 weeks	up to 30%	developmental
Venezuelan equine encephalitis	high	none	2-5 days	Low (-1%)	developmental
Hepatitis A	-	-	15-40 days	-	-
Hepatitis B	-	-	40-150 days	-	-
Influenza	high	none	1-3 days	usually low	available
Yellow fever	high	none	3-6 days	up to 40%	available
Smallpox (Variola)	high	high	7-16 days	up to 30%	available
Rickettsial					
Coxiella Burneti (Q-fever)	high	negligible	10-21 day	Low (-1%)	antibiotic
Mooseri -	-	6-14 days	-	-	
Prowazeki	-	-	6-15 days	-	-
Psittacosis	high	moderate-high	4-15 days	Mod-high	antibiotic
Rickettsi (Rocky mountain spotted fever)	high	none	3-10 days	up to 80%	antibiotic
Tsutsugamushi	-	-	-	-	-
Epidemic typhus	high	none	6-15 days	up to 70%	antibiotic/vaccine
Bacterial					
Anthrax (pulmonary)	mod-high	negligible	1-5 days	usually fatal	antibiotic/vaccine
Brucellosis	high	none	1-3 days	-25%	antibiotic
Cholera	low	high	1-5 days	up to 80%	antibiotic/vaccine
Glanders		high	none	2-1 days	usually fatal poor antibiotic
Meloidosis	high	none	1-5 days	usually fatal	moderate antibiotic
Plague (pneumonic)	high	high	2-5 days	usually fatal	antibiotic/vaccine
Tularemia	high	negligible	1-10 days	low to 60%	antibiotic/vaccine
Typhoid fever	mod-high	mod-high	7-21 days	up to 10%	antibiotic/vaccine
Dysentery	high	high	1-4 days	low to high	antibiotic/vaccine

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Table 4.7

Key Biological Weapons - Part Two

Disease	Infectivity	Transmissibility	Incubation Period	Mortality	Therapy
Fungal					
Coccidioidomycosis	high	none	1-3 days	low	none
Coccidiodes Immitis	high	none	10-21 days	low	none
Histoplasma Capsulatum	-	-	15-18 days	-	-
Norcardia Asteroides	-	-	-	-	-
Toxins[a]					
Botulinum toxin	high	none	12-72 hours	high neromuscular paralysis	vaccine
Mycotoxin		high	none	hours or days	low to high ?
Staphylococcus	moderate	none	24-48 hours	incapacitating	?

a. Many sources classify as chemical weapons because toxins are chemical poisons.

Source: Adapted by Anthony H. Cordesman from Report of the Secretary General, Department of Political and Security Affairs, Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use, New York, United Nations, 1969, pp. 26, 29, 37-52, 116-117; Jane's NBC Protection Equipment, 1991-1992; James Smith, "Biological Warfare Developments," Jane's Intelligence Review, November, 1991, pp. 483-487; USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 4-22 to 4-26.

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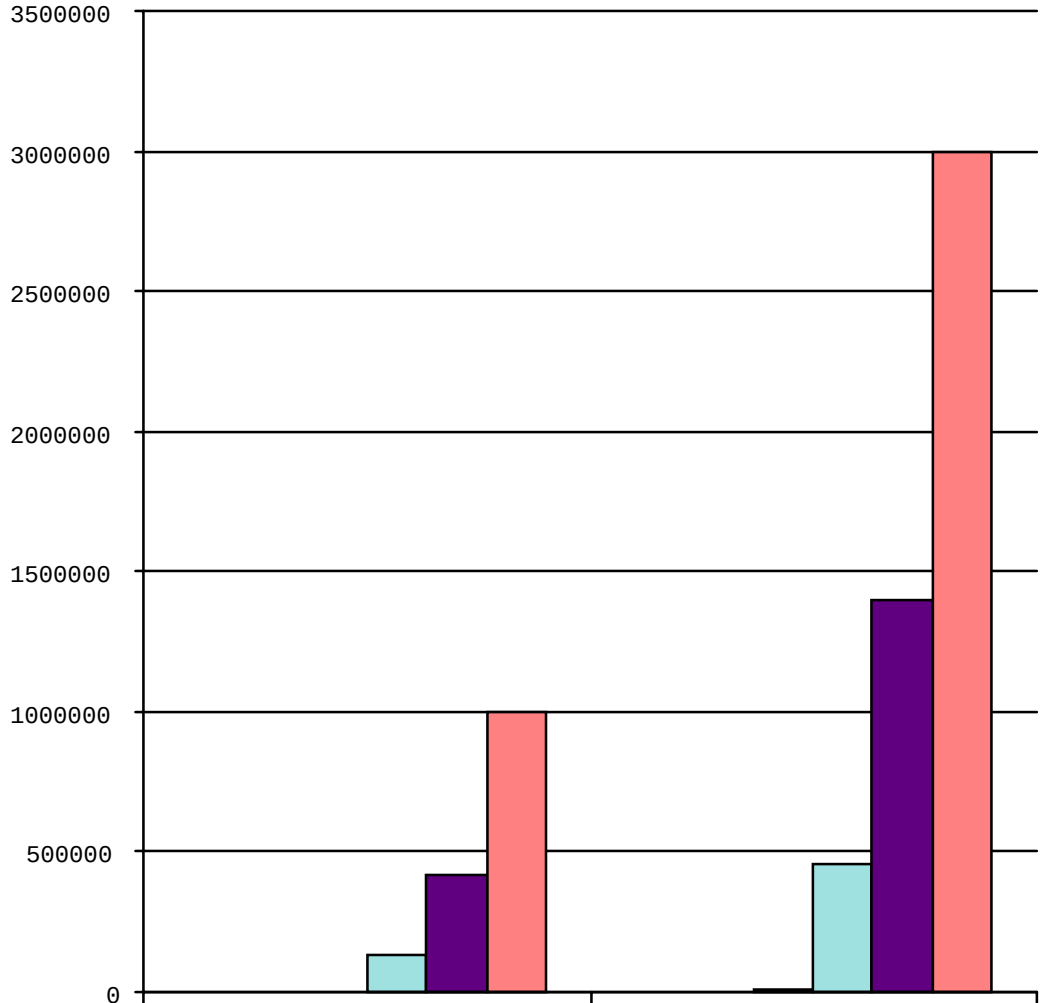
Chart 4.2

The Relative Killing Effect in Numbers of Dead for Biological vs. Chemical Weapons with a Optimal Aerosol Delivery



	Low	High
Sarin-Sun	300	700
Sairn-Shade	400	600
Sarin-Calm	3000	8000
Bio-Sun	130000	460000
Bio-Shade	420000	1400000
Bio-Calm	1000000	3000000

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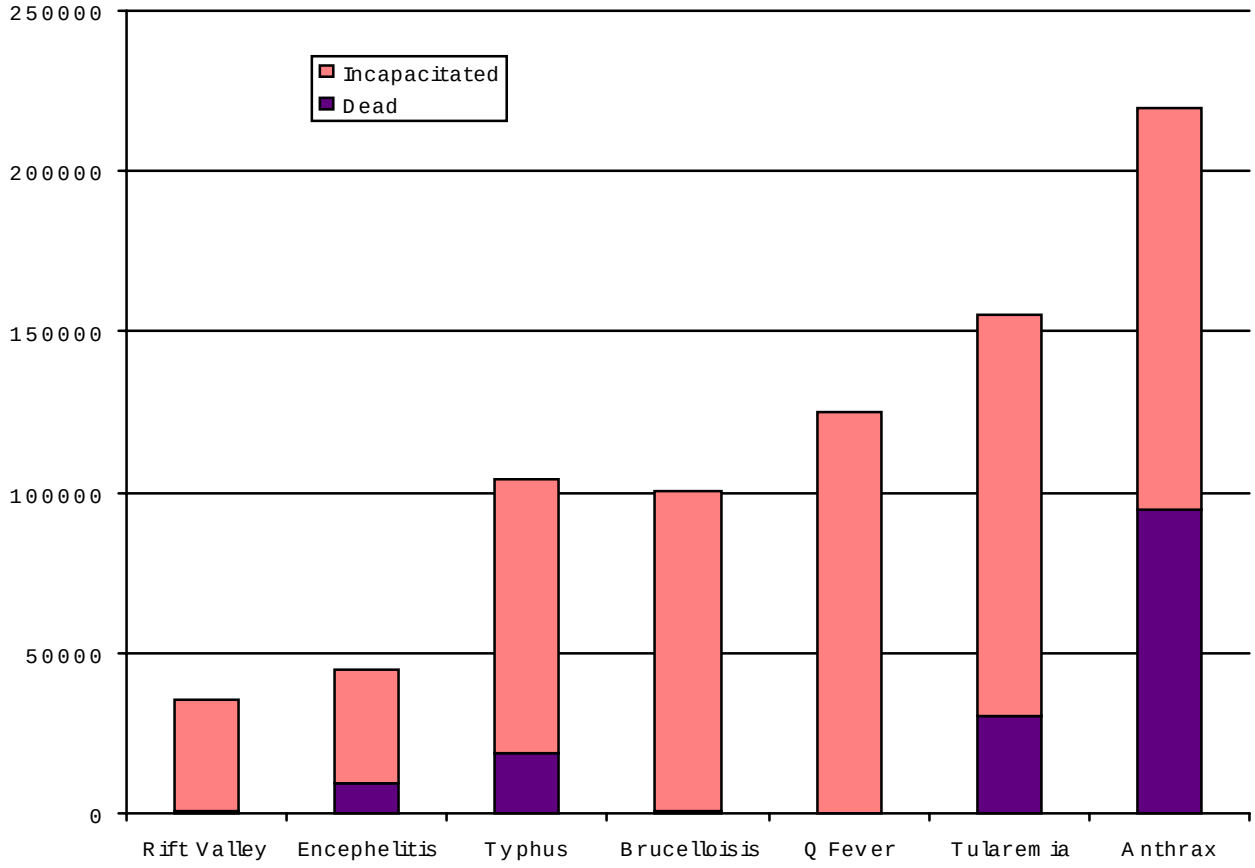
Chart 4.3

The Nominal Lethality of Different Biological Weapons _Part One

(Numbers of dead from delivery of 1,000 Kilograms)



Agent	Downwind Reach (kilometers)	Casualties Dead	Casualties Incapacitated
Rift Valley Fever	1	400	35,000
Tick-Borne Encephalitis	1	9,500	35,000
Typhus	5	19,000	85,000
Brucellosis	10	500	100,000
Q Fever	20+	150	125,000
Tularemia	20+	30,000	125,000
Anthrax	20++	95,000	125,000

Source: World Health Organization, Health Aspects of Chemical and Biological Weapons, WHO, 1970.

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Chart 4.3

The Nominal Lethality of Different Biological Weapons _Part Two

(Numbers of dead from delivery of 1,000 Kilograms)

20-90% Deaths in 1-10 Days	20%-100 Deaths in 5-20 Days	50%-100 Incapacity for Two Weeks
Anthrax (bc)	Brucellosis (c)	Brill-Zinsser disease
Bolivian hemor. fever	Blastomycosis	Dengue fever
Ebola infection	Congo Crim. hem. Fever (d)	Eastern equine encephalitis
Glanders (d)	Monkey herpes B	Epidemic typhus (d)
Lassa infection (d)	Korean hemor. fever (d)	Legionellosis
Marburg infection	Japanese encephalitis	Murine typhus
Plague (bd)	Monkeypox infection	Q fever (c)
Smallpox (abd)	Omsk hemor. fever (d)	Rift Valley fever
Yellow fever (b)	Russian S/S encephalitis	Salmonellosis
Melioidosis	Tularemia (bc)	Scrub typhus (d)
	Argentine hemor. fever (d)	
	Bolivian hemor. fever (d)	
	Influenze (d)	

a. Untreated. Days are numbers of days after symptoms appear.

b. Vaccine available – if not genetically altered

c. Known to be weaponized,

d. Probably weaponized.

Source: Dr. Kenneth Alibeck, "Biological Weapons Protection," Hadron, Inc. June 1, 2000, and USACHPPM, The Medical NBC Battlebook, USACHPPM Technical Guide 244, pp. 4-20 to 4-21.

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Table 4.8

The Effects of Iraq's Biological Weapons

Disease	Weapon	Main Symptoms	Incubation Period	Untreated Fatality Rate	Contagious?
Anthrax (Pulmonary) *Bacillus Anthrax*	Bacterial Spore in vapor or dry micro-powder	High fever, difficult breathing, rapid pulse, chest pains, shock, toxic blood poisoning	1-5 days	90% as a military agent. Antibiotics only effective after short period	No
Botulism *Clostridium Botulinum* bacterium	Botulinum toxin in vapor or dry micro-powder	Fatigue, nausea, headache, constipation, thirst, fever, cramps, dizziness, blurred vision, problems in swallowing, followed by respiratory paralysis and death	2-36 hours	65%	No
Gas Gangrene *Clostridium perfingens*	Vapor or mist	Enters open wounds, Toxins kill muscle muscle cells and cause bloating, shock, jaundice, and sometimes death	2-36 hours	25%	No
Aflatoxin	Powered mold or vapor	High concentrations can confuse and incapacitate, and later cause jaundice, internal bleeding, and liver cancer.	Hours to years	?	No
Ricin	Castor bean derivative in powder or vapor form. Can ingest or inject.	Can be insecticide or weapon. Kills cells and impedes breathing and circulation, causes nausea, vomiting, bloody diarrhea, stupor, convulsions, shock, liver damage and death.	10 Hours. Lethal amounts kill in two days	?	No
Plague, pneumonic *Yersina pestis* bacterium	Vapor, possibly dry powder	Infection of lungs, fever, headache, pneumonia. hemorrhages, heart failure.	2-5 days	95%	Yes, extremely.
Smallpox Variola virus	Vapor, possibly dry power	Headache, chills, fever, lesions of skin and mucous membranes	12 days	25-40%	Yes, extremely

Adapted by Anthony H. Cordesman from work by the Monterey Institute, CIA report of February 19, 1998, and Washington Post, February 22, 1998, p. A-28.

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