Part II

Defining the Problem: Potential Threats

CHAPTER 2

Threats from Biological, Chemical, Nuclear, and Radiological Weapons

LEARNING OBJECTIVES

By the end of this chapter, the reader will be able to:

- Define biological, chemical, radiological, and nuclear weapons.
- Understand the threats from and history of use of weapons of mass destruction.
- Characterize the current threat from weapons of mass destruction, specifically biological weapons, used by both state and nonstate actors.
- Identify the public health community's role in responding to weapons of mass destruction.

INTRODUCTION

In this chapter, we begin to explore and define the threats the public health community should be prepared to address. We begin with a focus on weapons of mass destruction (WMD), including chemical, biological, radiological, and nuclear (CBRN) weapons. While we will look at all of these types of weapons, our predominant focus will be on biological weapons because they are most directly linked to the public health and medical communities through detection, response, and recovery. However, for the public health and medical communities to be prepared for and to respond appropriately to these threats, they must work closely with communities that they may not have traditionally interacted with, particularly the security and defense communities—including law enforcement, military entities, the intelligence community, and the rest of the national and homeland security infrastructure. These communities, and specific interactions, will be discussed in more detail later in the book. Here, we present the WMD threats. We look first at chemical, then nuclear and radiological threats, and then focus more extensively on the details of biological weapons. The majority of this chapter and the rest of this text will center on the biological threat because this threat has the strongest links to public health preparedness.

CHEMICAL THREATS

Article II, paragraph 1, of the Chemical Weapons Convention (CWC), defines chemical weapons as one of the following, either in combination or separately:

> (a) Toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes;
>
> (b) Munitions and devices, specifically designed to cause death or other harm through the toxic properties of those toxic chemicals specified in subparagraph (a), which would be released as a result of the employment of such munitions and devices;
>
> (c) Any equipment specifically designed for use directly in connection with the employment of munitions and devices specified in subparagraph (b).[1]

In general, chemical warfare is the use of a chemical substance to directly harm or kill humans, plants,* or animals. Chemical agents are nonliving, manufactured chemicals.

* It is worth noting that the Chemical Weapons Convention does not include chemicals that harm plants. There is some debate over whether defoliants and other chemicals used against plants should be considered chemical weapons under international legal regimes.

They tend to be highly toxic and can enter the body through inhalation or through the skin. Adding to the complexity of treatment, illness or death can come within minutes of exposure or take as long as several hours.[2] As described in **Box 2-1**, there are four main categories of chemical warfare agents: blister (e.g., mustard gas), blood (e.g., cyanide), choking (e.g., chlorine), and nerve (e.g., sarin). In addition, a class, termed *riot control agents*, produce temporary, usually nonfatal, irritation of the skin, eyes, and respiratory tract. Riot control agents, often known as "tear gas," include chloroacetophenone (CN), chlorobenzylidenemalononitrile (CS), and chloropicrin (PS). The Chemical Weapons Convention and the U.S. government do not consider this class of agents to be chemical weapons. Other nations, however, disagree.[3]

TOXINS

Toxins are nonliving poisons produced by living entities, such as plants, fungi, insects, and animals. Because they are chemical by-products of biological agents, they occupy a conceptual gray area between chemical and biological weapons. The Biological Weapons Convention covers toxins, as does the Chemical Weapons Convention—or at least some toxins. This is another area where, for the purposes of arms control and legal international obligations, countries do not always agree on how toxins should be categorized.

BOX 2-1 Types of Chemical Agents

- *Nerve agents*—primarily act on the nervous system, causing seizures and death. Examples of this category include sarin, VX, tabun, and soman. This category also includes fourth-generation chemical weapons, known as Novichok agents, which are thought to be much more lethal than VX.
- *Blister agents, or vesicants*—primarily cause irritation of the skin and mucous membrane. Examples of this category include mustard gas and arsenical Lewisite.
- *Choking agents, or pulmonary toxicants*—primarily cause damage to the lungs, including pulmonary edema and hemorrhage. Examples include phosgene, diphosgene, and chlorine.
- *Blood agents*— in high doses, primarily cause seizures and respiratory and cardiac failure. Examples include hydrogen cyanide and cyanogen cyanide.

History

In April 1915, during World War I, in Ypres, France, the German army attacked the French with chlorine gas, marking the first large-scale use of chemical weapons during warfare. Several months later, in September 1915, the British used chlorine gas against the Germans at the Battle of Loos. This was followed in June 1918 by the first use of chemical warfare by the United States. It was clear that by the end of World War I, all sides were actively using the chemical weapons.[4] **Figure 2-1** shows soldiers in World War I suffering from the effects of chemical warfare.

Many nations continued to utilize chemical warfare throughout the 20th century, including the British use of Adamsite (a vomiting agent) against the Bolsheviks during the Russian Civil War, Spanish use of chemical weapons against rebels in Morocco in the 1920s, Italian use of mustard gas against Ethiopians in 1936, and the Nazi's use of hydrocyanic acid for the mass extermination of Jews and other concentration camp prisoners during World War II.[5]

During the Vietnam War, the United States used defoliants, such as dioxin, also known as "Agent Orange," as well as other normally nonlethal agents. The United States does not consider defoliants to be chemical weapons; therefore, it does not consider this use to be chemical warfare. High levels of morbidity and mortality from those exposed to the agents, though, have led to large research efforts and calls by many that this was, in fact, chemical warfare.[6,7]

While most of the cited examples of chemical weapons use have been large-scale warfare incidents, these agents have also been used throughout history as assassination tools.[8] One particularly illustrative example was the 1979 assassination of a Bulgarian exile, named Georgie Markov, described in **Box 2-2**.

Another example of the offensive use of chemical agents comes from the doomsday cult Aum Shinrikyo, based in Japan. On March 20, 1995, Aum Shinrikyo released sarin gas into the Tokyo subway system. Twelve people died, approximately 50 were severely injured, and almost 1,000 suffered temporary vision problems.[9] More than 5,500 people, however, sought medical attention, swarming area hospitals and testing public health capacities. This chemical weapons use event highlighted the importance of emergency preparedness, especially in the area of hospital surge capacity.

In addition to intentional releases of chemical agents, the accidental releases of agents have also posed significant challenges to public health and medical systems worldwide and have adversely affected the health of populations. For example, in 1981, cooking oil was accidentally adulterated with industrial rapeseed oil and distributed throughout southern

FIGURE 2-1 John Singer Sargent's painting, "Gassed" depicting WWI British Troops Blinded by a Chemical Weapons Attack, Battle of Estaires, April 10, 1918

Source: © Lebrecht Music and Arts Photo Library/Alamy Images.

Europe. More than 15,000 people became sick, and 203 died after people consumed the contaminated oil.[10(p xi)]

In some instances, the release of chemical agents may not have been entirely accidental, but one assumes that the public health consequences were unintentional. In 2006, a Panamanian-flag, Greek-owned, Swiss oil company–chartered tanker, the *Probo Koala*, avoiding European disposal fees, carried more than 500 tons of petrochemical waste to Côte d'Ivoire, which was then dumped by a local contractor in more than 12 different sites around Abidjan. Fifteen people died as a result of exposure to this toxic waste, 69 were hospitalized, and more than 100,000 sought medical treatment,[11] easily overwhelming the existing public health and medical infrastructures.[12] **Figure 2-2** shows a worker involved in trying to clean up the toxic waste.

Unfortunately, these types of exposures to chemical agents are not infrequent. On May 29, 2010, a worker at a scrapyard in Nigeria tried to cut a gas cylinder into pieces,

BOX 2-2 Assassination by Ricin

In 1978, a Bulgarian exile, named Georgie Markov, was waiting for a bus in London. A man poked him with the tip of an umbrella, apologized, and got into a taxi. Four days later Markov was dead.

Ten days prior to this incident, another Bulgarian exile, Vladimir Kostov, was shot in the back in Paris, and when he turned around, he witnessed someone running away with an umbrella. This particular umbrella had been adapted and rebuilt into a makeshift gun that fired ricin pellets from its tip. After learning of Markov's death, Kostov sought medical attention immediately. A doctor removed the pellet that had lodged in his back. Fortunately, the ricin that was contained within the pellet had not fully expelled into his bloodstream. The doctor successfully removed it and confirmed the presence of ricin; Kostov survived the incident.

One of the reasons ricin was such an effective assassination tool against Markov was that it was virtually impossible to detect what was killing him and authorities could have done little even if it was identified. Ricin, a poison extracted from castor beans, prevents cells in the body from making proteins; without proteins, cells die, which can eventually lead to death. Once someone is exposed, it can take up to 6 to 8 hours for symptoms to occur, depending on the route of exposure, and death can occur rapidly within 36 to 72 hours. The symptoms of ricin exposure include respiratory distress if inhaled, vomiting and diarrhea if ingested, and redness and pain of skin and eyes if absorbed through skin. There is no available antidote thus far, and the only treatment is supportive medical care.

Source: Centers for Disease Control and Prevention. Facts about Ricin. *Emergency Preparedness and Response*. March 5, 2008. Available at: http://www.bt.cdc.gov/agent/ricin/facts.asp. Accessed July 8, 2010; Carus WS. *Bioterrorism and biocrimes: The illicit use of biological agents since 1900*. Center for Counterproliferation Research, National Defense University, 2001.

FIGURE 2-2 A worker cleans up toxic sludge dumped by a tanker in Akuedo, Ivory Coast

Source: © Luc Gnago/Reuters/Landov.

resulting in an explosion that released a cloud of chlorine gas into the air, sickening 300 people, who eventually required medical treatment.[13]

The largest chemical agent accidental exposure took place on December 3, 1984, in Bhopal, India. A Union Carbide pesticide plant released 40 tons of methyl isocyanate (MIC) gas into the air in the middle of the night. Nearly 4,000 people died instantly, and the total number of deaths is estimated to be between 15,000 and 22,000. A total of 500,000 people were exposed, and as many as 120,000 continue to suffer detrimental health effects.[14]

Accidents that expose populations to chemical agents can occur anywhere, including the United States. For example, a community in Graniteville, South Carolina, was left with 9 dead and 250 injured after a train carrying toxic chemicals, including chlorine gas, crashed. Accidents such as this, as well as the additional events listed in **Table 2-1**, remind us that all public health communities, regardless of location, must have a level of awareness regarding preparedness for a variety of potential public health emergencies, including the need to know how to respond to an emergency.

NUCLEAR AND RADIOLOGICAL THREATS

Nuclear Weapons

A nuclear weapon that involves fission (the splitting of atoms), like the bomb that the United States dropped on Hiroshima, Japan, or the devastating weapons created and stockpiled by a small number of nations since, leaves a limited role for the public health community. If released, such weapons would instantly destroy people, buildings and anything else in the vicinity. A public health response would not be needed because the chances of survival would be minimal. The explosion, however, would leave behind large amounts of radioactivity. We discuss the challenge of radioactivity next.

Radiological Threats

A radiological event is an explosion or other release of radioactivity. Such an event might be caused by any of the following: a simple, nonexplosive radiological device; an improvised nuclear device designed to release large amounts of radiation with a large blast radius (such as a "suitcase bomb"); a dispersal device that combines explosive materials and radioactive material (such as a "dirty bomb"); or sabotage or other damage to a nuclear reactor that results in the release of radiation.[15]

Even a small dose of radiation can cause some detectable changes in blood. Large doses of radiation can lead to acute radiation syndrome (ARS). First signs of ARS are typically nausea, vomiting, headache, diarrhea, and some loss of white blood cells. These signs are followed by hair loss, damage to nerve cells and cells that line the digestive tract, and severe loss of white blood cells. The higher the dose of radiation, the less likely the person will survive. Those who do survive may take several weeks to 2 years to recover, and survivors may suffer from leukemia or other cancers.[16]

The public health implications of radiological exposure can be significant. In addition to all other functions, the public health community will be responsible for:

- Participating in shelter-in-place or evacuation decisions.
- Identifying exposed populations through surveillance activities.
- Conducting or assisting with environmental decontamination.
- Determining safety requirements for working in or near the site of the incident.
- Conducting near and long-term follow-up with exposed populations.[17]

To date, most radiological exposure has occurred via accidents. An often-cited event occurred in Goiânia, Brazil, in 1987. Two men were rummaging through an abandoned hos-

TABLE 2-1 Examples of Major Chemical Incidents (1974–2006)

Year	Location	Type of incident	Chemical(s) involved	Deaths	Injured	Evacuated
1974	Flixborough, United Kingdom	Chemical plant (explosion)	Cyclohexane 28	104	3,000	
1976	Seveso, Italy	Chemical plant (explosion)	Dioxin		193	226,000
1979	Novosibirsk, Russian Federation	Chemical plant (explosion)	Uncharacterized	300		
1981	Madrid, Spain	Foodstuff contamination (oil)	Uncharacterized	430	20,000	220,000
1982	Tacoa, Venezuela (Bolivarian Republic of)	Tank (explosion)	Fuel oil	153	20,000	40,000
1984	San Juanico, Mexico	Tank (explosion)	Liquified petroleum gas (LPG)	452	4,248	200,000
1984	Bhopal, India	Chemical plant (leak)	Methyl isocyanate	2,800	50,000	200,000
1992	Kwangju, Democratic People's Republic of Korea	Gas store (explosion)	LPG		163	20,000
1993	Bangkok, Thailand	Toy factory (fire)	Plastics	240	547	
1993	Remeios, Colombia	Spillage	Crude oil	430		
1996	Haiti	Poisoned medicine	Diethylene glycol	>60		
1998	Yaoundé, Cameroon	Transport accident	Petroleum products	220	130	
2000	Kinshasa, Democratic Republic of the Congo	Munitions depot (explosion)	Munitions	109	216	
2000	Enschede, Netherlands	Factory (explosion)	Fireworks	20	950	
2001	Toulouse, France	Factory (explosion)	Ammonium nitrate	30	>2,500	
2002	Lagos, Nigeria	Munitions depot (explosion)	Munitions	1,000		
2003	Gaoqiao, China	Gas well (release)	Hydrogen sulphide	240	9,000	64,000
2005	Huaian, China	Truck (release)	Chlorine	27	300	10,000
2005	Graniteville, United States of America	Train tanker (release)	Chlorine	9	250	5,400
2006	Abidjan, Côte d'Ivoire	Toxic waste	Hydrogen sulphide, mercaptans, sodium hydroxide	10	>100,000[a]	

[a] The number of consultations, not necessarily the number of people made directly ill.

Source: Modified from the World Health Organization. *The World Health Report 2007: A Safer Future—Global Public Health Security in the 21st Century,* 2007.

pital and found an old nuclear medicine source—a radioactive cesium-137 teletherapy head. They took it home, partially dismantled it, and eventually sold it to a scrapyard. The owner of the scrapyard discovered that the cesium capsule omitted a blue light; many came to see it, and children rubbed the material on their bodies to glow in the dark. Four people, including a young child, died from the exposure. Another 249 individuals suffered serious health consequences.[18]

The most serious radiation accidents have been associated with nuclear power plants. Sixty-three accidents have occurred at nuclear power plants, with the most serious occurring in Chernobyl, Ukraine. On April 26, 1986, at 1:23 a.m., Reactor 4 of the Chernobyl Nuclear Power Plant exploded, instantly killing three and sending a plume of radioactive fallout into the air, which eventually drifted over parts of the Soviet Union; eastern, western, and northern Europe; and eastern North America. Approximately 350,000 individuals had to be evacuated and resettled. Fifty-six people died as a direct result of the accident. Another 4,000 have died from cancers linked to radiation exposure.[19] **Figure 2-3** shows the power plant after the explosion, and **Figure 2-4** depicts the spread of radiation from the plant, as well as the areas that had to be controlled.

The public health community's immediate and long-term responsibility in response to the Chernobyl disaster was significant, including assessing the safety of the environment for human habitation, addressing the psychological impact of the disaster on affected populations, monitoring the long-term health and well-being of exposed populations, and planning for the treatment of untold numbers of current and future cancer patients.[19,20]

More recent, on March 11, 2011, a 9.0 magnitude earthquake and subsequent tsunami hit the east coast of Japan, causing widespread damage and loss of life, crippling the Fukushima Daiichi Nuclear Power Station. The full impact of this nuclear plant disaster is not yet fully known, but local populations had to be evacuated from their homes; radioactive iodine and cesium have been found in locally produced foods; and drinking water, seawater, soil, and air must be continually monitored.[21]

FIGURE 2-3 An Aerial View of Ukraine's Chernobyl Nucler Power Plant, Taken in May 1986, Several Days after the Explosion on April 26, 1986

Source: © AP Photos.

FIGURE 2-4 Radiation Contamination after the Chernobyl Disaster

Source: Central Intelligence Agency. "Radiation Contamination after the Chernobyl Disaster," Making the History of 1989, Item #173, http://chnm.gmu.edu/1989/items/show/173 (accessed March 3, 2011, 9:30 a.m.).

In addition to the public health risk of accidental radiological exposure, the global community continues to be concerned about the intentional use of a nuclear or radiological device. In April 2010, President Barack Obama called the global community to a Nuclear Security Summit, where the nations of the world clearly acknowledged the threat of nuclear terrorism. President Obama delivered the following statement:

> Two decades after the end of the Cold War, we face a cruel irony of history—the risk of a nuclear confrontation between nations has gone down, but the risk of nuclear attack has gone up.
>
> Nuclear materials that could be sold or stolen and fashioned into a nuclear weapon exist in dozens of nations. Just the smallest amount of plutonium—about the size of an apple—could kill and injure hundreds of thousands of innocent people. Terrorist networks such as al Qaeda have tried to acquire the material for a nuclear weapon, and if they ever succeeded, they would surely use it. Were they to do so, it would be a catastrophe for the world—causing extraordinary loss of life, and striking a major blow to global peace and stability.
>
> In short, it is increasingly clear that the danger of nuclear terrorism is one of the greatest threats to global security—to our collective security.[22]

The International Atomic Energy Agency (IAEA) receives, on average, a report every 2 days on an incident of illicit trafficking of nuclear or radiological material.[23] Unfortunately, the nuclear and radiological threat is very real, and it is essential that the public health community be prepared.

BIOLOGICAL THREATS

The biological threat can be thought of as a continuum, including everything from naturally occurring diseases to the intentional release of a biological agent. This book will focus on the threat from natural disease and emerging and pandemic threats in later chapters; in this chapter, we focus exclusively on the intentional threat. *Biological warfare* (BW) is the military use of a biological agent to cause death or harm to humans, animals, or plants. In warfare, the targets of biological agents are typically governments, armed forces, or resources that might affect the ability of a nation to attack others or defend itself. Similarly, *bioterrorism* (BT) is the threat or use of a biological agent to harm or kill humans, plants, or animals. Unlike BW, though, the target of BT is typically the civilian population or resources that might affect the civilian economy, and the aggressor is often a nonstate actor. *Agroterrorism* refers to the knowing or malicious use of biological agents to affect the agricultural industry or food supply.[24]

As with chemical and radiological threats, there is a long history of the intentional use of biological agents. One example that is cited regularly comes from the 1346–1347 siege by Mongols of the city of Kaffa, now Feodosija, Ukraine. The Mongols reportedly catapulted corpses contaminated with plague over the walls of the city, causing an outbreak of *Yersinia pestis*.[25] Another history example comes from 1767 when British troops gave smallpox-infested blankets to Native Americans, causing a massive outbreak of smallpox among this unexposed population.

There was little use of biological weapons during World War I. In fact, the only reported use was by Germany, who used anthrax and glanders to infect Allied livestock.[26(p 513)] After WWI, however, the Japanese began a robust offensive biological weapons program, housed in what was called "Unit 731." This unit was based in Harbin, Manchuria, and conducted extensive research and experiments, often using prisoners of war as subjects. In 1940, the Japanese dropped rice and wheat mixed with plague-carrying fleas over China and Manchuria, leading to localized plague outbreaks. In 1942, the United States began its offensive biological weapons program. (See **Box 2-3**.)

Several additional high-profile biological weapons events occurred starting in the late 1970s. In 1979, in the Siberian town of Sverdlovsk in the Soviet Union (now Yekaterinburg), at least 77 people became ill with anthrax, resulting in 66 fatalities. Originally, the Soviet Union claimed that the cause of the outbreak was bad meat and the route of infection gastrointestinal. In reality, the cause of the outbreak was human error—someone forgot to replace a filter—at a military installation that was producing anthrax for offensive purposes. The anthrax escaped into the air, and those who became ill fell within the wind plume leading directly from the military compound, as depicted in **Figure 2-5**. In 1992, Boris Yeltsin admitted to the international community that the source of the anthrax in this outbreak came from the offensive military production site and not from consumption of infected meat.[27,28(p 163)]

Other events linked to the Soviet Union occurred during the same time period. Starting in 1976 in Laos, 1978 in Cambodia, and 1979 in Afghanistan, there were reports of chemical or toxin weapons use against the Hmong, Khmer, and Mujuhadin, respectively (see **Figure 2-6**). The alleged attacks were often said to begin with a helicopter or plane flying over

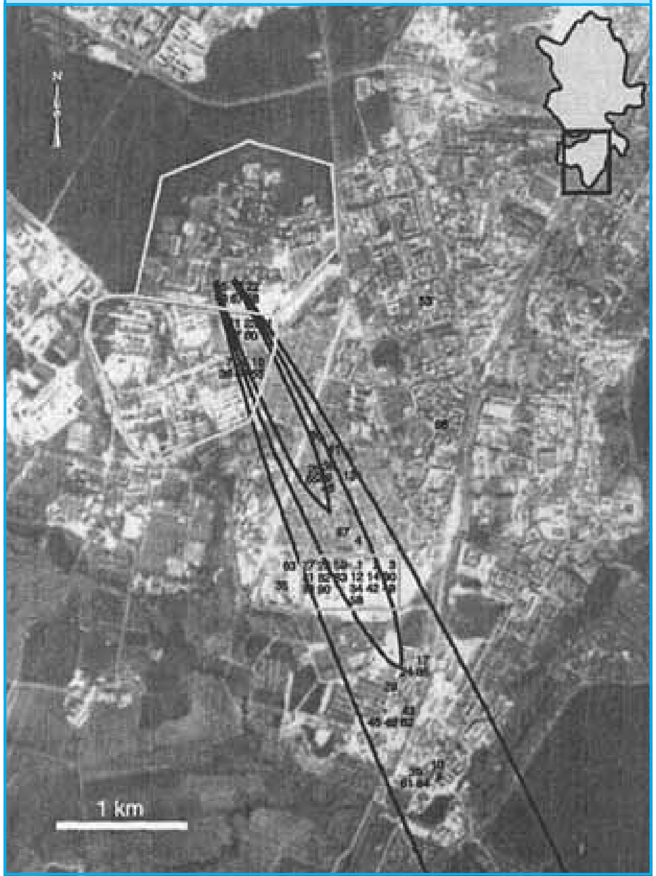
BOX 2-3 U.S. Offensive Biological Warfare Program, 1942–1972

1942	The National Academies of Sciences Biological Warfare Committee recommends that the United States should develop an offensive and defensive biological weapons program. Secretary of War Henry L. Stimson recommends to the president that a civilian organization be set up to run the program, and the president approves. The War Research Service (WRS) is established, and George Merck accepts the leadership position.
1943	A biological weapons research and development facility is constructed in Frederick, Maryland, at Camp Detrick, and becomes operational. Research begins on the offensive potential of botulinum toxin and anthrax.
1944	The biological warfare program is transferred from the WRS to the War Department. The War Department divides the program between the Chemical Warfare Service (CWS) and the U.S. Army Surgeon General. CWS works mostly on offensive research and production, while the Surgeon General focuses more on defensive measures. The research and development program is housed at Camp Detrick. An existing industrial plant near Terre Haute, Indiana, is acquired for conversion to a biological weapons production plant. Research on biological agents is expanded to include brucellosis, psittacosis, tularemia, and glanders.
1946	The War Department publicly acknowledges that the United States has developed an offensive biological weapons program.
1950	Several open-air sea tests are conducted using simulants. Field testing is also conducted at Dugway Proving Ground. The construction of a production facility at Pine Bluff Arsenal is authorized.
1950–1960	Research and production of at least seven biological agents continues. Airborne testing continues, and the program is expanded.
1960–1970	Funding for the biological warfare program starts to decline, but the army continues to work on antipersonnel, antiplant, and antianimal agents and runs several open-air tests using simulants in populated areas. The program also works on developing vaccines for defensive purposes.
1969	President Richard Nixon directs the National Security Council to review the chemical and biological weapons policy. The Senate Armed Services Committee votes to zero-out funding for the biological weapons program and prohibit additional open-air testing. On November 25, President Nixon renounces the development, production, stockpiling, and use of biological warfare agents. The Department of Defense is ordered to destroy existing biological weapons and engage in research only for defensive purposes.
1971–1973	The United States destroys all biological warfare agents and munitions.
1972	The United States signs the Biological and Toxin Weapons Convention.
1975	The Senate approves and the president ratifies both the Biological and Toxin Weapons Convention and the Geneva Protocol of 1925.

Sources: The Henry L. Stimson Center. History of the US Offensive Biological Warfare Program (1941–1973). *Biological and Chemical Weapons.* Available at: http://www.stimson.org/topics/biological-chemical-weapons/. Accessed July 10, 2010; and Smart JK. History of Chemical and Biological Warfare: An American Perspective. *Textbook of Military Medicine: Medical Aspects of Chemical and Biological Warfare.* Washington, DC: Office of the Surgeon General, US Department of the Army; 1989.

a village or resistance group and release of a colored gas that would fall in a manner that often looked, felt, and sounded like rain. The most common color reported was yellow, and thus the collective name for these incidents became "Yellow Rain." The alleged causative agent was trichothecene mycotoxin (T2), and the alleged supplier of this toxin was the Soviet Union, who provided it to the Pathet Lao in Laos, to the Vietnamese for use against Khmer resistance groups in Cambodia, and for direct use by the Soviets in Afghanistan. High levels of morbidity and mortality were associated with the allegations

FIGURE 2-5 Wind Plume from Military Installation Allegedly Producing Anthrax in Sverdlosk and the Location of Anthrax Cases in 1979



Source: Meselson, M.J., J. Guillemin, M. Hugh-Jones, et al. (1994), The Sverdlovsk Anthrax Outbreak of 1979, *Science*, 266, no. 5188:1202–1208.

of Yellow Rain. In 1982, the United States estimated that more than 10,700 people had been killed. Some estimated the loss of life to be much greater, particularly within the Hmong community. Some estimates go up to 20,000, and the Lao Human Rights Council puts the number as high as 40,000.[29,30]

The first large-scale bioterrorist event in the United States occurred in 1984 in The Dalles, Oregon. The Rajneeshee Cult, living in the area at the time, wished to influence a local election. Their plan was to make people in the town too sick to show up to vote in the election, have all of the members of the cult vote, and thereby vote their candidate into office. As a trial run, cult members infected multiple salad bars in local restaurants with salmonella. As a result, 751 people became ill, and 45 were hospitalized. This case demonstrates how difficult it is to distinguish between a naturally occurring event and an intentional release of an agent, which enables plausible deniability on the part of the perpetrators. Members of the Epidemic Intelligence Service (EIS) from the CDC were called in to help with the investigation. While the EIS officers felt that something was not right with the outbreak, they were unable to definitively say that the cases were not of natural origin. It was not until a year after the event, when a member of the cult confessed to authorities, that the public health officials were able to fully understand the nature of the outbreak.[31,32]

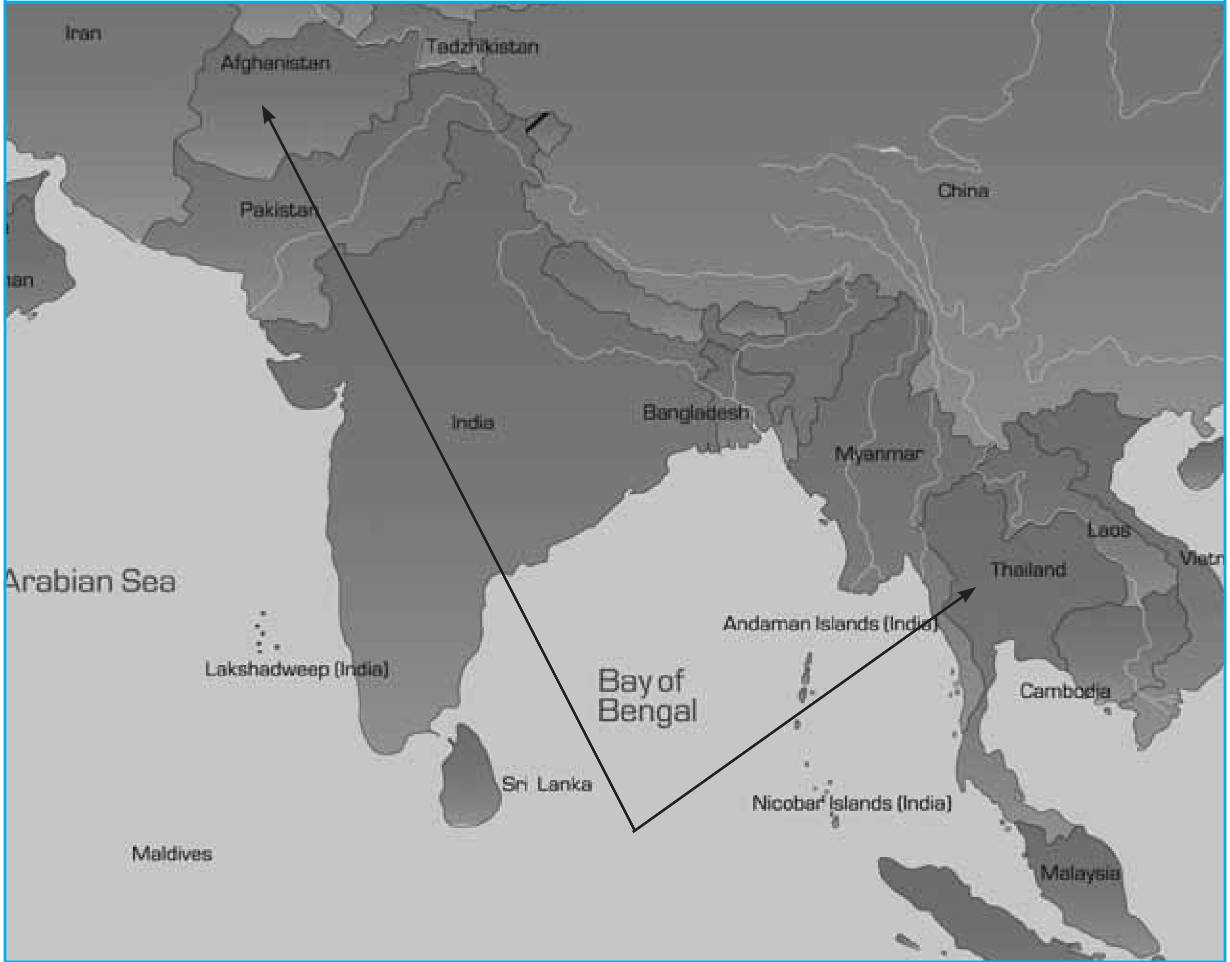
The most well-known bioterrorism event in the United States occurred in the fall of 2001, just weeks after the 9/11 attacks. The case, eventually named "Amerithrax" by the Federal Bureau of Investigation (FBI), involved finely milled anthrax sent through the mail, targeting senators and media outlets. **Figure 2-7** shows pictures of two of the anthrax letters, and **Figure 2-8** is the epidemic curve of the attacks and subsequent cases. In all, 22 people became ill and 5 died. Thousands of postal workers, congressional staff, and other potentially exposed individuals received prophylactic antibiotics and were offered vaccines. Thousands more were potentially exposed during this incident, and many more who were worried about possible effects of exposure demanded antibiotics from their personal physicians. Vast sums of money were spent decontaminating post office facilities and Senate office buildings. In 2010, the FBI finally closed the Amerithrax case, claiming the perpetrator was a U.S. government researcher at Fort Detrick, named Bruce Ivins. Dr. Ivins committed suicide before being formally charged and thus never stood trial.

The total disruption caused by what was—in the end—the equivalent of about a sugar packet amount of anthrax is impressive. The vast infrastructure and funding that came about in response to the attack was even more impressive. This will be discussed more fully in subsequent chapters.

Biological Agents

For a biological agent to be an effective weapon, it should ideally (from the perpetrator's perspective) have high toxicity; be fast acting; be predictable in its impact; have a capacity for survival outside the host for enough time to infect a victim; be relatively indestructible by air, water, or food purification; and be susceptible to medical countermeasures available to the attacker but not to the intended victim(s). Of the many biological agents that exist in nature (including parasites, fungi and yeasts, bacteria, rickettsia and Chlamydia, viruses, prions, and toxins), most effort is directed at a small group of bacteria, viruses, and toxins as the primary source of potential biological weapons. (See **Box 2-4**.)

FIGURE 2-6 Locations of Alleged Yellow Rain Attacks



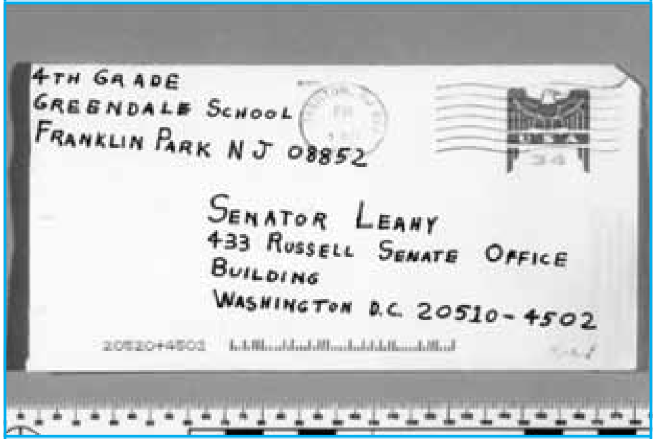
Source: © Hemera/Thinkstock.

Classification of Biological Agents

Two major characterizations are used to classify biological agents. The first, used more by policy planners at the federal level, looks at the spectrum of agents and defines them as:

- *Traditional:* Traditional agents are naturally occurring microorganisms or toxins that have long been connected with bioterrorism or biological warfare either because they have been used in the past or they have been studied for use. There are a finite number of agents that are relatively well understood. The policy and public health community has devised specific plans to address the potential use of these agents. Examples include smallpox and anthrax.
- *Enhanced:* Enhanced agents are traditional biological agents that have been altered to circumvent medical countermeasures. This group includes agents that are resistant to antibiotics.
- *Emerging:* This category includes any naturally occurring emerging organism or emerging infectious disease. Examples include severe acute respiratory syndrome (SARS), H5N1, and novel H1N1.
- *Advanced:* The final category on the spectrum of biological threats encompasses novel pathogens and other artificial agents that are engineered in laboratories. It is virtually impossible to plan for the specific threats posed by this category of agents, thus forcing policy makers to look at biological threats with a much broader strategic approach.

FIGURE 2-7 One of the Anthrax Letters Sent to Senator Leahy



Source: Reproduced from the Department of Justice.

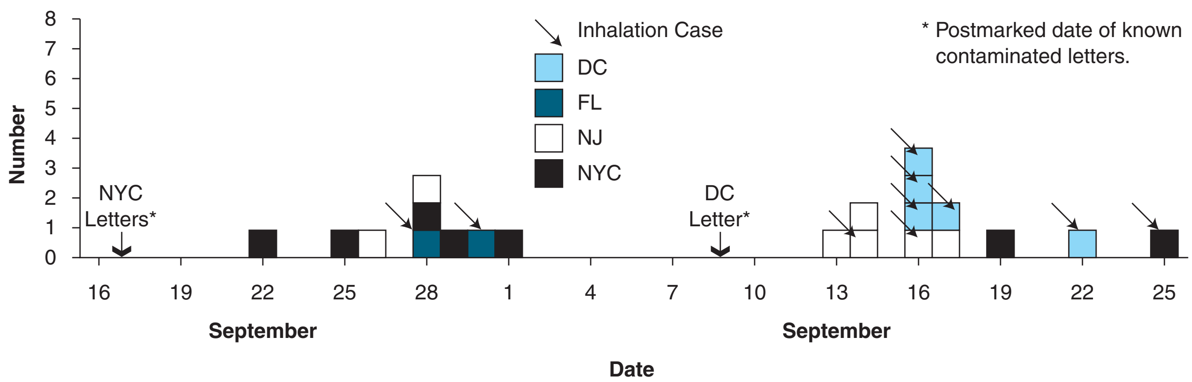
BOX 2-4 Biological Agents in Nature

Bacteria	Free-living unicellular organisms
Viruses	Core of DNA or RNA surrounded by a coat of protein; require host cell to replicate; much smaller than bacteria
Toxins	Toxic substances produced by living organisms

The second classification method for biological threat agents is the Category A, B, and C list, shown in **Box 2-5**. (Pictures of several agents from this list can be found in **Figures 2-9 to 2-14**.) This categorization originated with a 1999 CDC Strategic Planning Workgroup, which looked at the public health impacts of biological agents, the potential of those agents to be effective weapons, public perception, fear, and preparedness requirements. They also examined existing lists, including the Select Agent Rule list, the Australia Group list for export control, and the World Health Organization list of biological weapons.[33]

The resulting lists begin with Category A, which includes the highest-priority pathogens with the highest threat. They can cause large-scale morbidity and mortality and often require specific preparedness plans on the part of the public health community. Category B includes the second-highest threat group. Most of the agents in this category are waterborne or foodborne. These agents have often been intentionally used in the past or were part of offensive research programs. The morbidity and mortality from these agents are not as significant as from Category A agents, but still considerable, and they often require the public health community to enhance surveillance and diagnostic capacity. The last group is Category C, which encompasses emerging pathogens or agents that have become resistant to medical countermeasures. These agents may cause high morbidity and mortality and may be easily produced and transmitted.[34]

FIGURE 2-8 Number of Bioterrorism–Related Anthrax Cases, by Date of Onset and Work Location. District of Columbia (DC), Florida (FL), New Jersey (NJ), and New York City (NYC), September 16–October 25, 2001



Source: Reproduced from *MMWR* November 2, 2001/50(43); 941–948.

BOX 2-5 Category A, B, and C Threat Agents

Category A

- *Bacillus anthracis* (anthrax)
- *Clostridium botulinum*
- *Yersinia pestis* (plague)
- Variola major (smallpox) and other pox viruses
- *Francisella tularensis* (tularemia)
- Viral hemorrhagic fevers
  - Arenaviruses
    - LCM, Junin virus, Machupo virus, Guanarito virus
    - Lassa Fever
  - Bunyaviruses
    - Hantaviruses
    - Rift Valley Fever
  - Flaviruses
    - Dengue
  - Filoviruses
    - Ebola
    - Marburg

Category B

- *Burkholderia pseudomallei*
- *Coxiella burnetii* (Q fever)
- *Brucella* species (brucellosis)
- *Burkholderia mallei* (glanders)
- Ricin toxin (from *Ricinus communis*)
- Epsilon toxin of *Clostridium perfringens*
- Staphylococcus enterotoxin B
- Typhus fever (*Rickettsia prowazekii*)
- Food- and waterborne pathogens
  - Bacteria
    - Diarrheagenic *E. coli*
    - Pathogenic Vibrios
    - *Shigella* species
    - *Salmonella* species
    - *Listeria monocytogenes*
    - *Campylobacter jejuni*
    - *Yersinia enterocolitica*
  - Viruses (Caliciviruses, Hepatitis A)
  - Protozoa
    - *Cryptosporidium parvum*
    - *Cyclospora cayatanensis*
    - *Giardia lamblia*
    - *Entamoeba histolytica*
    - Toxoplasma
    - Microsporidia
- Additional viral encephalitides
  - West Nile Virus
  - LaCrosse
  - California encephalitis
  - Venezuelan equine encephalitis
  - Eastern equine encephalitis
  - Western equine encephalitis
  - Japanese Encephalitis Virus
  - Kyasanur Forest Virus

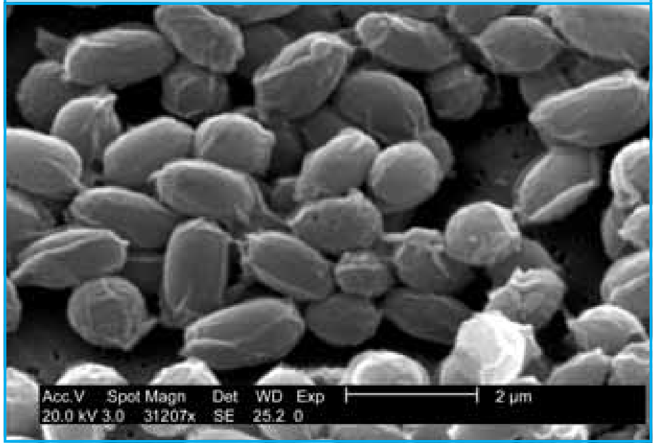
Category C

- Emerging infectious diseases (including Nipah)
- Tickborne hemorrhagic fever viruses
  - Crimean-Congo hemorrhagic fever virus
- Tickborne encephalitis viruses
- Yellow fever
- Multi-drug-resistant TB
- Influenza
- Other Rickettsias
- Rabies
- Severe acute respiratory syndrome–associated coronavirus (SARS-CoV)
- Antimicrobial resistance disease (excluding sexually transmitted diseases)

Source: Centers for Disease Control and Prevention. Bioterrorism Agents/Diseases—By Category. *Emergency Preparedness and Response.* Available at: http://www.bt.cdc.gov/agent/agentlist-category.asp. Accessed July 10, 2010.

Biological weapons are unique from other potential weapons of mass destruction in that the agents themselves are relatively available because many occur naturally and may be endemic in some parts of the world. The technology to work with these agents has progressed to a point where knowledge is widespread, and those with minimal formal education may possess the skills to work with and maliciously use certain agents. Compared with other weapons of mass destruction, biological weapons are inexpensive. While it is extraordinarily complicated to distribute biological weapons through a missile or other munition, other means of dissemination are quite easy (e.g., spraying salad bars). Intentional

FIGURE 2-9 Bacillus Anthracis

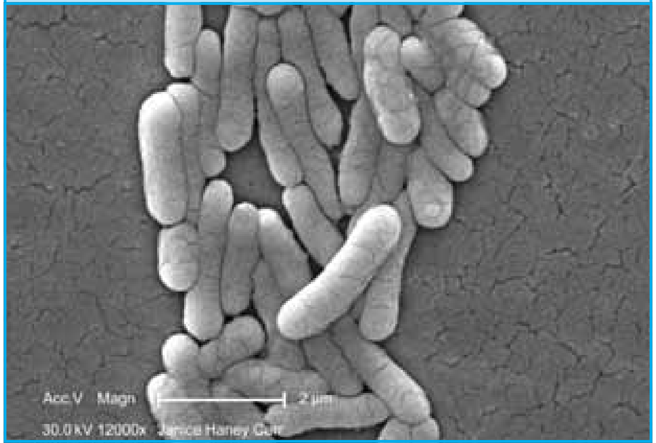


Source: Reproduced from CDC Public Health Image Library; CDC/Laura Rose.

FIGURE 2-10 Ebola Virus

Source: Reproduced from CDC Public Health Image Library; CDC/Frederick Murphy.

FIGURE 2-11 Salmonella

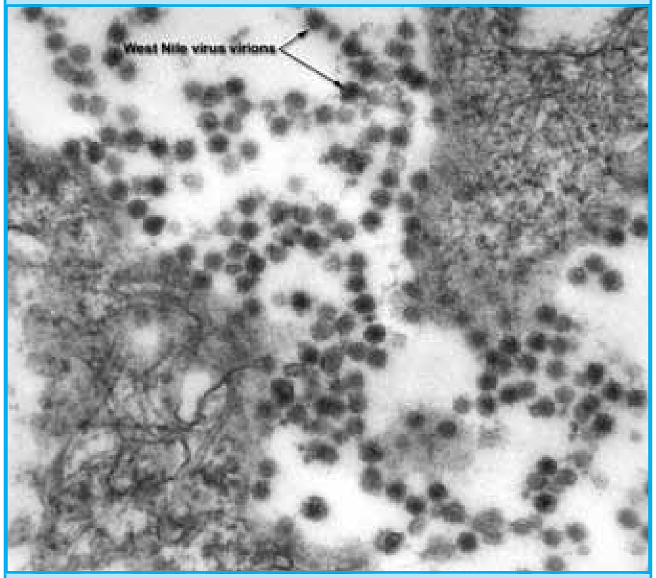


Source: Reproduced from CDC Public Health Image Library; CDC/Bette Jensen.

FIGURE 2-12 Giardia Protozoan

Source: Reproduced from CDC Public Health Image Library; CDC/Dr. Stan Erlandsen.

FIGURE 2-13 West Nile Virus



Source: Reproduced from CDC Public Health Image Library; CDC/ P.E. Rollin.

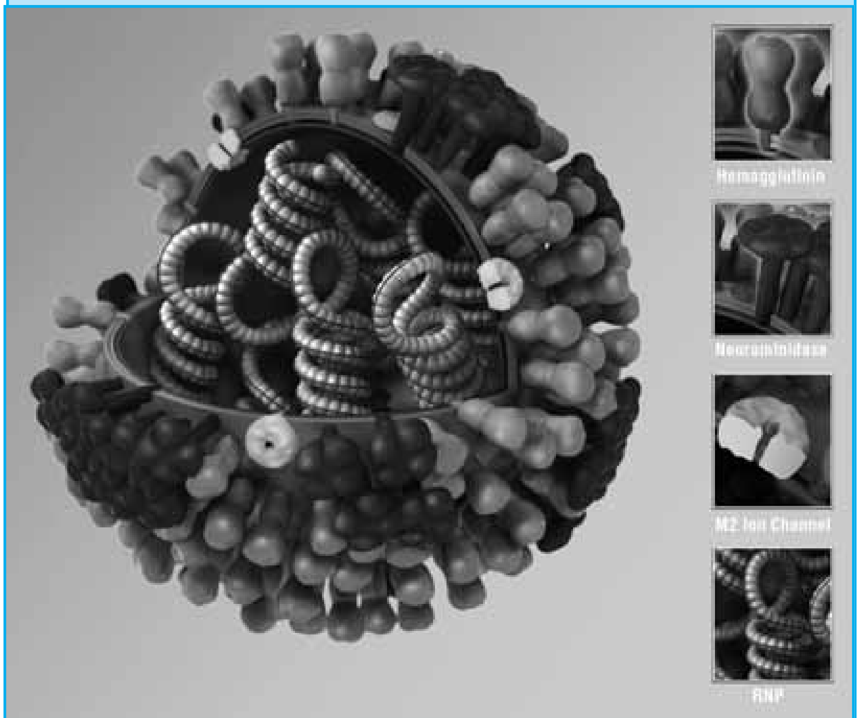
attacks may be very difficult to detect and differentiate from a naturally occurring event, thus allowing for plausible deniability on the part of the offender.

Finally, biological weapons can be extremely lethal. A 1993 study by the now-defunct Congressional Office of Technology Assessment concluded that a crop duster plane flying over Washington, D.C., and disseminating 100 kg of anthrax powder had the potential to be more deadly than a 1-megaton hydrogen bomb. (See **Figure 2-15**.) An earlier study by the World Health Organization using a similar scenario of a line source dissemination of agent from an airplane also demonstrates the large-scale morbidity and mortality that can result from the intentional release of a biological weapon, as depicted in **Table 2-2**.

The Biological Threat

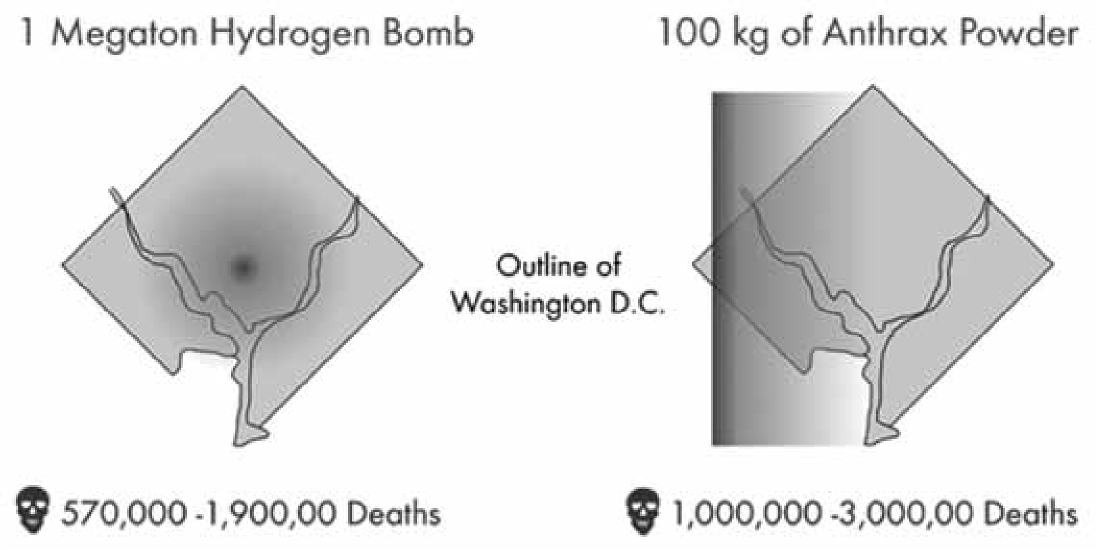
In December 2008, the Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism released the *World at Risk* report, in which they concluded there will likely be a biological attack some place in the world within the next 5 years, and biological weapons are to be considered a threat of primary importance to the United States.[35]

FIGURE 2-14 Influenza Virus



Source: Reproduced from CDC Public Health Image Library; CDC/ Doug Jordan, M.A.

FIGURE 2-15 Lethality of Anthrax Compared to a Nuclear Weapon. 1993 Study by the Congressional Office of Technology Assessment



Source: U.S. Congress, Office of Technology Assessment, Proliferation of Weapons of Mass Destruction: Assessing the Risk, OTA-ISC-559 (Washington, DC: U.S. Government Printing Office, August 1993). Pages 53–54.

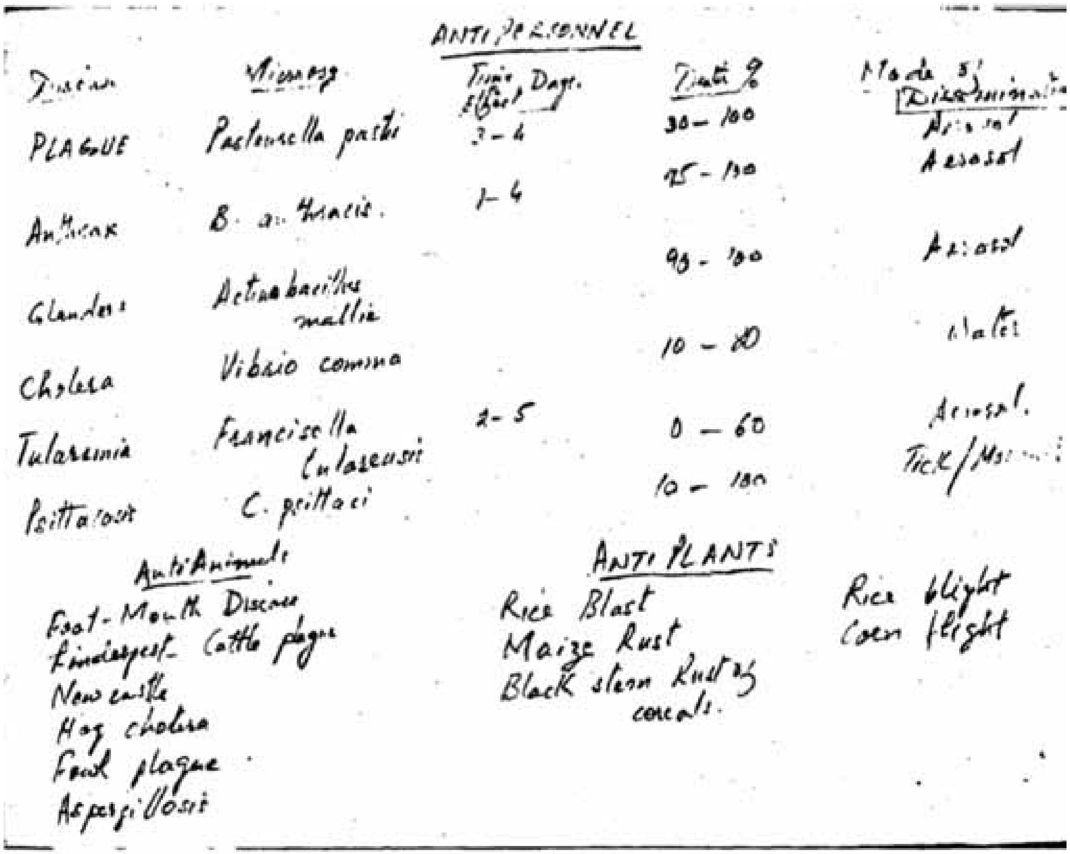
The threat of a biological weapons attack derives from multiple sources. An attack may be carried out by a lone actor, a terrorist group or an organization, or a state-sponsored program. At one point in time, there were probably a dozen nations that sponsored offensive biological weapons programs. Many fewer programs exist today,[36] but the agents created and knowledge gained from state-sponsored offensive programs have become threats unto themselves, as terrorist organizations lure scientists with financial incentives. For example, the former Soviet Union had an extensive offensive biological weapons program, spanning the military, KGB, and civilian sectors. In the civilian program, called Biopreparat, there were up to 40,000 scientists and technicians all working on biological weapons research and production.[37] This program was inherited by Russia after the fall of the Soviet Union, although in 1992 President Boris Yeltsin promised to

TABLE 2-2 Analysis of Morbidity and Mortality That Would Result from an Airplane Release of 50 kg of Agent Along a 2 km Line Upwind of a Population Center of 500,000

Agent	Downwind Reach (km)	Casualties	Dead
Rift Valley Fever	1	35,000	400
Tickborne enceph.	1	35,000	9,500
Typhus	5	85,000	19,000
Brucellosis	10	100,000	500
Q-fever	>20	125,000	150
Tularemia	>20	125,000	30,000
Anthrax	>>20	125,000	95,000

Source: Adapted from Health Aspects of Chemical and Biological Weapons, WHO, 1970.

FIGURE 2-16 Document Recovered from al Qaeda Facility at Tarnak Farms, Afghanistan



Source: U.S. Department of Defense, Office of the Assistant Secretary of Defense (Public Affairs). Enduring Freedom Operational Update—Rear. Adm. Stufflebeem; Wednesday, October 31, 2001 - 1:30 p.m. EST.

terminate the program. While much effort and money have gone toward redirecting former weapons scientists into more peaceful lines of work (see description of cooperative threat reduction programs later in this book), it is unclear whether all of the scientists involved in the program or the materials they worked with are accounted for. Thus, the threat of knowledge and agents moving to other nations or terrorist organizations remains.

Terrorist organizations also present a significant threat that biological weapons will be used. As previously mentioned, the Rajneeshee cult successfully engaged in bioterrorism, as did Aum Shinrikyo. In addition to the sarin gas attack, Aum Shinrikyo had attempted to use biological weapons but was unsuccessful in causing any injuries (they used a vaccine strain of agent that would not cause disease and utilized inefficient dissemination mechanisms). When police raided their compound after the sarin attack, they found cultures of anthrax and botulism and spray tanks.[38]

Al Qaeda has yet to use biological weapons but has expressed interest in this means of terrorism. The United States found a facility in Afghanistan that had been used by al Qaeda, possibly to experiment with or eventually produce a biological weapon. At this location, called Tarnak Farms, several documents were found, including analyses of the potential casualties from different agents and notes about where to acquire seed cultures. (See **Figure 2-16**.) In addition to al Qaeda, at least 11 other terrorist organizations have expressed interest in using biological weapons.[39]

Overall, the current threat posed by biological weapons has increased significantly in the past decade. The potential consequences of an attack would go beyond population morbidity and mortality and could include such disruptions as a shutdown or slowdown of international travel and trade, economic shocks, potential civil disorder, public panic or confusion, and national or regional instability.

This text will examine the role of the public health community in addressing these threats and some of the challenges faced. Multiple sectors of society must work together to effectively prevent, prepare for, and manage the consequences of an attack, but the core of any effective detection and response capacity is public health. It is the public health community that can identify an event through population surveillance and clinical reporting. The public health community is central in mounting a response that treats those who are ill, protects those who may have been exposed, addresses immediate and long-term health consequences, and reconstitutes the infrastructure after the event has occurred.

KEY WORDS

Biological weapons
Bioterrorism
Chemical weapons
Radiological weapons
Toxins
Intentional use
Accidental exposures

Discussion Questions

1. Do you agree with the *World at Risk* report that there will be a biological attack in the next 5 years? Why or why not?
2. What role would the public health community play if a radiological weapon was dispersed in a major metropolitan area?
3. Do you believe the public health community is aware of the threats from weapons of mass destruction? If not, what would you do to remedy the situation, and what information do you think would be important for public health professionals to know?
4. Do you believe the public health community is aware of or prepared for the potential for accidental chemical, biological or radiological exposure in its communities?
5. How should public health professionals communicate with security officials to be kept aware of the latest threats? Is that an appropriate role for public health?

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