ELSEVIER

Technology in Society xx (xxxx) 1–23

Technology In Society

www.elsevier.com/locate/techsoc

Understanding technologies of terror

Victoria Sutton[a], D. Allan Bromley[b,Ⱶ,*]

[a]*Texas Tech University School of Law, 1802 Hartford Avenue, Lubbock, TX 79409, USA*
[b]*Yale University, P.O. Box 208124, New Haven, CT 06520, USA*

Abstract

The variety of weapons of mass destruction are intended to create the maximum possible fear, death, destruction, and general terror in the target region or nation, particularly with new and creative ways of using them. An understanding of how these weapons work, the ways they may be used, and the scope of their destruction can contribute to effectively combating their effects. This article examines these weapons—nuclear, electromagnetic pulse, radiological, chemical and biological technologies—as well as policy approaches to defending against them. The development of national programs directed toward the understanding, potential use, and response to weapons of mass destruction by the United States, Japan and the Soviet Union are reviewed and compared, as are the international agreements that have thus far addressed the possible use of such weapons.

Keywords: Nuclear and chemical explosives; Electromagnetic pulse weapons; Chemical and biological weapons; Weapons of mass destruction; WMD

1. Introduction

The 20th century has witnessed dramatic changes in the kinds of weaponry available for national and international conflicts as well as potential targets for that weaponry. Although some of the agents have been known since the Dark Ages, the technologies necessary for their development, effective use, and delivery have undergone major change. In this paper, we focus on what are referred to generically as weapons of mass destruction (WMD). This term includes nuclear, electromagnetic pulse, radiological, chemical, and biological weapons of various kinds and because the American public has relatively little

* Corresponding author. Tel: +1 806 742 3990; fax: +1 806 742 0251.
E-mail address: vickie.sutton@ttu.edu (V. Sutton).
Ⱶ Deceased.

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doi:10.1016/j.techsoc.2005.04.002

information—and in some cases, substantial misinformation—about each of these weapons, there is widespread confusion and misunderstanding that make it difficult to develop coherent and effective policies for detection and response to future attacks. This is especially true because attacks involving these weapons have widely different characteristics, and each weapon system cannot be addressed effectively under any generic WMD approach.

Policy makers and administrators, as well as our citizens, began to scrutinize our approach to possible attack ever since the terrorist attacks of September 11, 2001 on the World Trade Center in New York and the Pentagon in Washington, and the subsequent anthrax attacks on national leaders in both politics and the media. All these require a more introspective examination of our national policy approach to responding to these threats. As just noted, while anthrax has been known for a long time, the technologies for delivery of this and other WMD, both long- and short-range, including intercontinental ballistic missiles, cruise missiles, and the production of aerosols essential to weaponizing biological agents, are of far-reaching importance. Table 1 compares the loss of life involved in a wide variety of catastrophes and gives some context for this discussion.

Table 1
Comparison of life loss in major world catastrophes

Date	location	Cause	No. of victims
1347–1351	Europe	Black Plague, pandemic	25 million
1520	South America, Aztecs	Smallpox brought by Spaniards	35 million
1556	Shaanxi, China	Earthquake	830,000
1815	Mount Tambora, Indonesia	Volcanic Eruption	160,000
1876–1879	Northern China	Famine	10 million
1914–1918	Mainly in Europe	First World War	20 million
1918	Entire World	1918 Flu Pandemic	20–100 million[a]
1917	Halifax Harbor, Canada	Accidental chemical explosion	1654
1931	Huang He Basin, China	Flood	3.7 million
1939–1945	Entire World	Second World War	40 million
1945	Hiroshima, Japan	Nuclear Weapon Explosion	140,000
1945	Nagasaki, Japan	Nuclear Weapon Explosion	90,000
1970	Bangladesh	Cyclone	300,000
1980	Entire World	AIDS	>3 million persons per year seropositive
1984	Bhopal, India	Chemical Discharge	5000
1986	Chernobyl, Soviet Union	Nuclear Power Plant Accident	30,000
2004	Southeast Asia	Tsunami	300,000
?	Entire World	Nuclear War	1 billion perhaps

Sources: Adapted from Sagan, Turco. *A path where no man thought: nuclear winter and the end of the arms race*. Random House; 1990.

[a] Gina Kolata, Flu: *The story of the great influenza pandemic of 1918 and the search for the virus that caused it*. Farrar, Straus and Giroux, New York; 1999.

We will consider separately each of the weapon systems as potential threats. It is essential to bear in mind that the purpose of a WMD is to create maximum fear, death, destruction, and general terror in the target region or nation. For example, nuclear attacks would cause both human deaths and infrastructure destruction; biological attacks would cause human fatalities while keeping the infrastructure intact. All these weapons are designed to cause terror and destruction in the target region and they become even more frightening because of the new and creative ways that terrorists choose to use them. The weapons used in the September 11, 2001 attacks—large, fully fueled jet airliners—represent a new and unanticipated approach to terrorism. Cyberterrorism—the destruction of communications infrastructure—can be used in conjunction with any of these weapons systems to magnify their effectiveness.

WMD has traditionally been addressed as a singular threat by national security policy analysts. Most terrorist activity had occurred outside the US, and little focus was placed on domestic activity prior to September 11, 2001. National security concerns outside the US were addressed by the CIA; terrorism inside the US borders was addressed by the FBI. Then, via Presidential Decision Directives 39 and 62 (PDD 39, PDD 62) [10], the Clinton Administration designated the FBI as the lead agency to respond to acts of terrorism. The FBI's traditional mission, however, has been criminal investigation, which is not an optimal approach for addressing situations involving WMD, each of which requires knowledgeable leadership with a specific set of interdisciplinary and multi-agency responses.

The Department of Homeland Security, established on March 7, 2003, is an important component of the US response to terrorist attacks of all kinds (Fig. 1). From its inception, the department realized there are many aspects of terrorist activity that are the clear responsibility of the federal government. However, the balance of federal and state powers

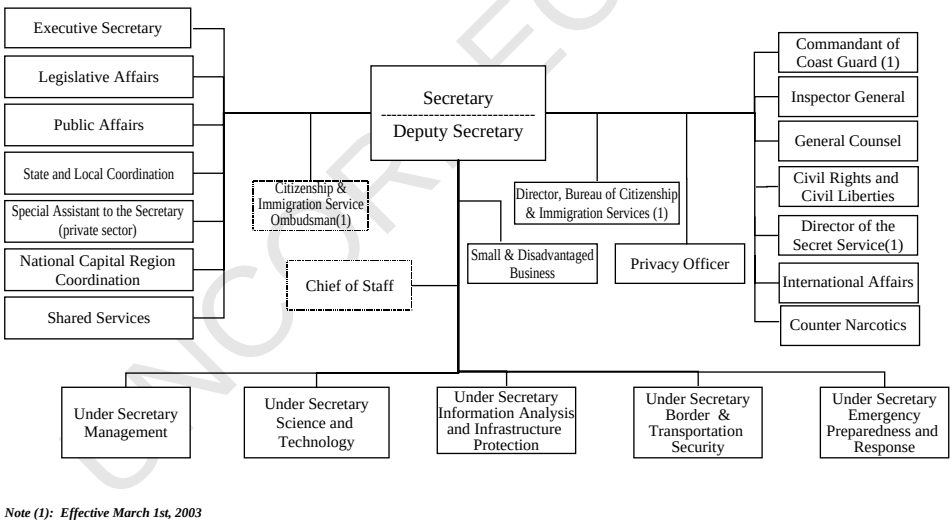

Fig. 1. Organizational chart for the Department of Homeland Security (as of Aug. 2004). Source: <http://www.dhs.gov/interweb/assetlibrary/DHS_OrgChart_2004.pdf>. Site visited 03/21/05.

provided for in the US Constitution reserves exclusively to the states the powers to regulate and manage public health except where there is a 'substantial effect on interstate commerce' [11]. This separation of powers and its consequent lack of coherent planning for response to any terrorist attack is one of the most serious weaknesses of our current response policies.

2. Nuclear weapons

Nuclear explosives were first used by the United States in 1945 to end World War II in the Pacific. The 10-kilotons uranium weapon (60 pounds of enriched U-235) detonated at Hiroshima, and the 22-kilotons plutonium weapon (6 pounds of plutonium) subsequently used at Nagasaki, essentially destroyed both cities, although both weapons were small and crude by modern standards [5, p. 59].

Because a typical nuclear reaction releases roughly one million times the energy of a typical chemical reaction, the impact of a nuclear explosion is qualitatively different from that of a chemical explosion. Nuclear fission weapons are based on the explosive fission of small masses of U-235 (a 0.7% abundant isotope of natural uranium) or Pu-239 (which is produced by neutron bombardment of U-238, the 99.3% abundant isotope of natural uranium) in a nuclear reactor. A typical modern nuclear weapon contains about 1 kg of U-235 or Pu-239, and if this fuel was fully expended, the weapons would have a yield equivalent to the explosion of 17 million kilograms of the most powerful chemical explosive. It would also produce 8 g of neutrons; i.e. 4.8×10^{24} neutrons [5, p. 59].

In either case, the technical problem is bringing together a critical mass of fissile material and holding its components together long enough so that the resulting neutron-induced chain reaction can burn a significant amount of the available material before the explosion blows the critical mass apart. As an example, the Hiroshima weapon had 60 kg of U-235 and the critical mass was assembled by firing two sub-critical masses together in a gun-barrel configuration using high-explosive drivers to bring the components together and hold them there. Thus the observed yield was only 10 kilotons equivalent of chemical explosives which was only 0.3% efficient. Only 8 kg of U-235 were actually involved in the fission process, and the remaining 52 kg were distributed as part of the fallout from the blast. In contrast, the Nagasaki bomb had 6 pounds of Pu-239. Imploding chemical explosives, symmetrically arranged around the plutonium, compressed and held it in a critical mass, yielding a 22-kilotons equivalence with an efficiency of 20% [5, p. 65]. Both Japanese cities were almost totally destroyed.

Today, all nuclear fission weapons in Russia, America, and the other developed countries are based on implosion technology. Those developed in South Africa use the gun-type technology, and it is possible that terrorists from rogue nations might return to the gun-type U-235 approach in the absence of plutonium or the high-level technology required for an implosion weapon.

The first implosion technology was developed in the labs at Los Alamos, NM under the direction of Seth Nedermeyer, a physics professor from Indiana University. It was tested at Alamagordo, New Mexico in July 1945 prior to its use in the Nagasaki weapon. It bears noting that no comparable test of the gun-type weapon used at Hiroshima was considered

necessary because the Los Alamos scientists were quite confident that it would perform as expected. It was recognized from the outset, however, that the original implosion design was much more complicated and delicate because of the exquisite time required for firing and placement of the chemical explosive so that the compression of the plutonium core would proceed with adequate symmetry.

Another major change came out of the work of Stanislaw Ulam and Edward Teller. The chemical explosives used as the implosion device for the lithium deutride (LiD) core were replaced by an enormous flux of soft X-rays from a trigger nuclear fission weapon. This had major advantages: the trigger weapon added its yield to the primary fusion weapon, and the interaction of the neutrons from both weapons with the uranium casing that focused the X-rays from the trigger explosion on the primary weapon added to the total yield.

In the weapons arsenals of Russia, the US, France, Britain, Israel, and other members of the nuclear club, uranium and plutonium fission bombs have been largely replaced by bombs fueled by heavy isotopes of hydrogen. The reason is that uranium- and plutonium-fueled weapons are limited in size and power by the need to hold the critical mass together, while hydrogen fusion weapons have no limit on their size or power.

The US tested its first hydrogen weapon in 1952 on the Eniwetok Atoll in the Pacific Ocean, and produced a yield of 10 megaton of TNT equivalent [5 (p. 64), 4]. In 1961, the Soviet Union tested its first hydrogen weapon, which resulted in a yield of 60 megatons—equivalent to about 4600 Hiroshima weapons. If, as originally planned, it had been surrounded by a uranium shell, the yield would have been about 100 megatons [5, p. 65]. This was the largest nuclear weapon ever tested; if it had ever been used, for example, on New York City, it would have destroyed the entire Boston-to-Washington corridor.

Typical nuclear weapons in both the Russian and US arsenals were designed to yield about 0.5 megatons equivalent. In 1967, the US had over 33,000 such warheads, but that number has now been reduced to about 12,000. In 1986, the Soviet Union (now Russia) had 45,000 such warheads and still has about 18,000. On May 24, 2002, President George W. Bush and President Vladimir Putin of Russia signed the 'US–Russian Treaty on Strategic Offense Reductions' during Bush's visit to Moscow.

One matter of considerable concern is whether, following the collapse of the Soviet Union, it has been possible to account for all the Soviet warheads. Since that time, there have been terrorist threats to use such Russian warheads on both East and West Coast American cities—threats that were either baseless or forestalled! In 1993, the US contracted to buy 500 tons of 90% enriched U-235 from Russia to prevent its dispersal elsewhere. The intention is to use the material to fabricate fuel rods for US electric power reactors by reducing the U-235 enrichment from 90 to 5% with U-238.

It is worth noting that 20 of the above 0.5 megaton warheads could kill about 25 million people in either the US or Russia, with larger US cities facing greater vulnerability. This fact was the basis for the so-called MAD (Mutually Assured Destruction) policy, which while considered totally unacceptable by many on humanitarian grounds did prevent the use of nuclear weapons during the latter half of the 20th century. Unfortunately, for terrorists there is no equivalent deterrence since terrorists can choose the weapon, time, and place for an attack, and it is rarely possible to identify the source.

In the late 20th century, continuing research and development on nuclear weapons resulted in more compact systems with specialized characteristics. At one end of the spectrum are the so-called 'clean' or neutron weapons, designed to minimize blast and maximize neutron yield. The intent of such a weapon is to kill all humans in its target zone while leaving the physical infrastructure essentially intact for reuse after a relatively short period of decontamination and the natural decay of neutron-induced radioactivity. At the other end of the spectrum is the so-called 'dirty' bomb, which is relatively easy to put together by surrounding any normal nuclear weapon with a shell of, for example, cobalt metal. When detonated, such a device produces vast quantities of the isotope cobalt-60 (with a half-life of about 5.3 years) and emits very powerful gamma rays with nearly two million electron volts of energy (this is the isotope used in food sterilization and medical radiation devices). Use of such a 'dirty' nuclear weapon renders its target zone uninhabitable for at least a half-century, with the dimensions of the zone depending on the size of the nuclear weapon used.

Major progress has been made in terms of shrinking the size and weight of nuclear fission weapons to the point where they can be fitted into artillery shells and cruise missiles and even, as is rumored in the case of a special Russian KGB weapon, into a briefcase [12]. Technological developments have also resulted in more effective intercontinental ballistic missile systems that deliver nuclear warheads through the MIRV (Multiple Independent Re-entry Vehicle) process. In this case, the so-called missile 'bus' typically carries 10 independently targetable thermonuclear warheads [5 (p. 337), 13, 8] so a single intercontinental ballistic missile can, in principle, largely obliterate 10 different cities in the target country. Fig. 2 shows a cross-section of the declassified W87 American nuclear warhead. Ten of these warheads could be carried by a single ballistic missile and independently directed to 10 preprogrammed targets.

3. Electromagnetic pulse weapons

Early in the Manhattan Project, it was recognized that detonation of nuclear devices in the atmosphere or stratosphere could result in widespread disruption of power lines, communication networks, even railroad tracks and metal fencing. It was not, however, until the Johnson Island test at high altitude that the true magnitude of this effect was first appreciated.

If a standard 0.5 megaton warhead was to be detonated, some 300 km above the center of the United States, the gamma rays from the detonation, interacting with electrons in the atoms of the earth's atmosphere, could produce an almost instantaneous electromagnetic pulse (EMP) covering the entire country. The magnitude of the pulse would depend on the size of the nuclear weapon used and its altitude when detonated. The voltage pulse has a rapid onset, rises to its maximum value in something like a nanosecond, and then falls off rapidly thereafter. Such a pulse would induce devastating voltage surges in any large network and would have an extraordinary destructive effect on both communications and power distribution systems.

The major impact of an EMP would be its impact on semiconductor devices that are generally highly sensitive to overload and burnout, which would occur in the input stages

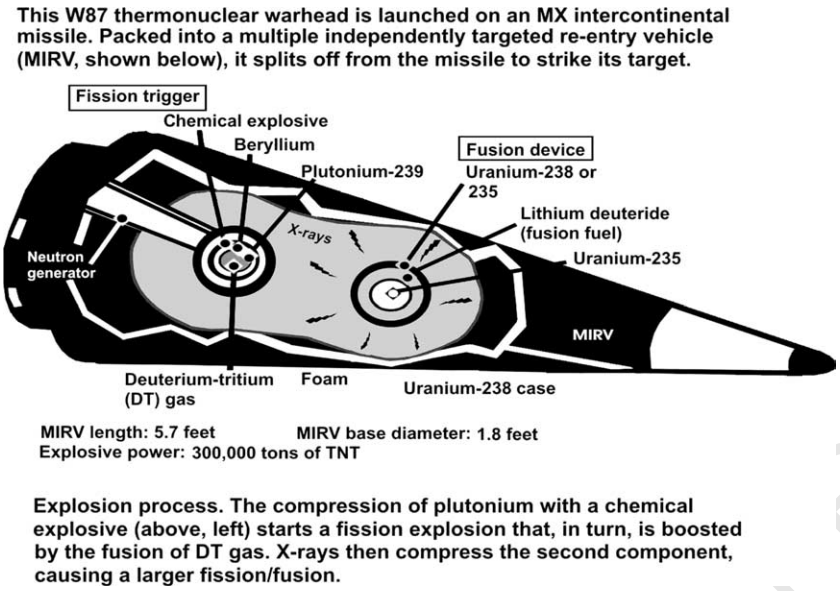

Fig. 2. A modern thermonuclear explosive. Source: From a declassified, redacted version of the *Report of the Select Committee on US National Security and Military/Commercial Concerns with the People's Republic of China*. Submitted by Mr Cox of California, Chairman. US House of Representatives, 105th Congress, 2nd Session, Report 105-851. Washington, DC: US Government Printing Office, 1999.

of almost any electronic device unless it had been specifically 'hardened' through metallic shielding or highly sophisticated geometric design to minimize the effective antennae characteristics of the device. Such damage would destroy a country's communication and computation systems, as well as many other systems including cellphones. A single nuclear detonation at high altitude would result in an EMP that would essentially 'blind' and 'deafen' an entire country.

During the Cold War, both the Soviet Union and the US recognized that such a high-altitude nuclear attack would be a likely first step in any major nuclear exchange owing to its effective paralyzing of the target nation's ability to respond. In that sense, the EMP is very much a weapon of mass destruction. But is it of interest as a potential terrorist weapon? It is known that a significant number of Soviet warheads of the appropriate size are missing and may well have fallen into the hands of major terrorist groups. Since a missile capable of delivering such a weapon can be relatively crude with no special targeting capabilities or high-precision requirements, such missiles are probably already available in a number of national programs worldwide. Combining a pre-existing warhead with such a missile would be well within the capability of any major terrorist group. Thus, although its use would not lead to direct fatalities in the target nation, the resulting confusion and chaos are almost beyond imagining and would likely cause many indirect fatalities. There is no current evidence suggesting that any of the known terrorist groups are planning to use an EMP weapon, but hardening of components of the national

communication, computation, and control systems beyond those already hardened by the military and national security programs would be one approach to reduce the impact of an EMP attack.

4. Radiological weapons

There is considerable confusion regarding the differences between (and therefore the effects of) nuclear and radiological weaponry. In the latter case, there is no active nuclear reaction involved; instead a powerful chemical bomb is covered with a shell of radioactive material, such as cobalt-60, which may have been stolen from medical sources or from spent fuel rods obtained from any of the storage pools of every operating nuclear power reactor. When a chemical bomb explodes, the radioactive shell is disintegrated and spreads over a region, dependingupon the size of the chemical explosive device used.

Radiological weapons are important because, in principle, it is much simpler for a terrorist to obtain or assemble such a weapon than a true nuclear weapon. In the period since September 11, 2001, there have been major alerts in the United States because of unconfirmed reports that radiological weapons had been smuggled into New York and Washington. In both cases, the reports later proved to be incorrect, but this potential use of a radiological weapon to contaminate a major city remains a real possibility.

In the US and much of the world, there is an irrational fear of radiation, particularly nuclear-produced radiation. To put the risk of exposure to radiation into better perspective, Table 2 notes the relatively negligible risk when compared to other more common risks.

5. Chemical weapons

The origin of chemical weaponry is lost in the mists of history, although there are relatively reliable records that the Chinese used arsenic smoke in battle as early as 1000 BC, and that Solon of Athens put hellebore roots into the drinking water of Cirrha in 600 BC. In 429–424 BC, the Spartans and their allies used noxious smoke and flame against Athens and its allied cities during the Peloponnesian Wars, and around 200 BC, the Carthaginians used mandrake root steeped in wine to sedate the Roman enemy. Leonardo da Vinci proposed a powder of sulfide of arsenic and verdigris as a weapon for use in the 30-Years War in Europe [14].

Almost every poisonous chemical in the Periodic Table has been suggested at one time or another for use in warfare. In the 20th century, the most familiar examples are mustard gas and chlorine, used by the Germans against Allied soldiers in France during World War I. More recently, a variety of nerve gases, such as VX, sarin, and ricin, have been developed and used for example, by the Iraqis against their Kurdish citizens in 1988 [15, p. 226, 256], and ineffectively by a Japanese cult *Aum Shinrikyo* in an attack on the Tokyo subway system in 1995 [15 (p. 19), 16], which proved fatal for 12 people and injured 5500 others. If sarin gas had been used, the death toll could have reached hundreds of thousands. Chemical weapons work effectively only when the target population is in an enclosure, as in a subway.

Table 2
Loss of life expectancy (LLE), in days, due to various risks

Activity or risk	Days LLE
Male rather than female	2800
Heart disease	2100
Unmarried	2000
Black rather than white (in the US)	2000
Smoking (one pack of cigarettes/day)	1600
Coal miner	1100
Cancer	980
30 pounds overweight	900
Grade-school dropout	800
Poor	700
Stroke	520
15 pounds overweight	450
All accidents	435
Vietnam army duty	400
Living in the southeastern US (S. Carolina, Mississippi, Georgia, Louisiana, Alabama)	350
Mining or construction work (due to accidents only)	320
Motor vehicle accidents	200
Pneumonia, influenza	130
Alcohol	130
Suicide	95
Homicide	90
Occupational accidents (average)	74
Driving a small car (versus standard size)	50
Drowning	40
Driving 65 vs. 55 mph	40
Falls	39
Poison + suffocation + asphyxiation	37
Fire, burns	27
Having a diet drink (one/day throughout life)	12
Radiation worker, age 18–65	11
Firearms	2
All electric power in US, nuclear (UCS)[a]	1.5
Hurricanes, tornadoes	1
Airline crashes	1
Dam failures	0.5
Spending lifetime near nuclear power plant	0.4
All electric power in US, nuclear (NRC)[b]	0.03

Source: Bernard L. Cohen, *Before It's Too Late*. Plenum Press; 1983. p. 92.
[a] Union of Concerned Scientists (UCS) estimate.
[b] Nuclear Regulatory Commission (NRC) estimate.

Vesicants, such as mustard gas, cause damage by absorption through the skin or breathing into the lungs, resulting in permanent damage or death. Nerve gases attack the central nervous system, rendering the subject unable to function, and in most cases cause death [14, p. 35]. Ricin is one of the deadliest toxins known, and can be reasonably easily produced by anyone with an elementary knowledge of chemistry. However, because of major problems with effective distribution, it has been little used as a weapon—although

the Russians reportedly found it a convenient agent when administered via the point of an umbrella to eliminate Russian defectors in Britain [17].

In 1991, at the end of the first Gulf War (Desert Storm), it was found that Iraq had 150 tons of sarin, 411 tons of mustard gas, and sufficient precursors to produce 500 tons of VX (a nerve gas similar to sarin and ricin). It was also found that Iraq had 10,000 l of concentrated botulinum toxin, 8400 l of anthrax spores, and 340 l of concentrated *Clostridium perfrengens* (the bacterium that causes gas gangrene) [4 (p. 56), 18]. It is far from clear what happened to these weapons following the ouster of UNSCOM investigators in 1996, and records of their destruction were not found in the 2002–2003 UN inspections. Operation Iraqi Freedom (also referred to as the second Gulf War) has thus far revealed a number of chemical and biological laboratories and records of their production, but no evidence of their present locations or of the destruction of these inventories of weapons.

6. Biological weapons

Biological weapons have a long history both in warfare and in terrorism. The most important biological agents are smallpox, caused by a virus (*Variola major*); anthrax, caused by a bacterium (*Bacillus anthracis*); and plague, caused by a bacterium (*Yersinia pestis*). A number of other biological agents, including tularemia, botulism, and hemorrhagic fevers (Ebola and Marburg strains) were weaponized in the former Soviet Union, and possibly in Iraq and other nations. There are 53 biological agents identified as potential biological weapons [7].

6.1. Smallpox

Among biological weapons, smallpox is by far the most deadly and worrisome. Ancient Chinese records describe smallpox in 1122 BC and Pharaoh Ramses V of Egypt died of it in 1157 BC. The disease reached Europe from China in 710 AD with horrible consequences. Similar episodes occurred when the Spaniards first arrived in America. Hernando Cortez brought smallpox to the Aztec Indian communities in 1520 AD and 35 million Aztecs died during the following two years [4 (p. 72), 6]. In the United States in 1763, Colonel Henry Bouchet presented smallpox-infected blankets to the Native Americans during Pontiac's Rebellion, killing thousands. Sir Jeffrey Amherst, Commander of the British forces in North America, used the same technique in New England with the same results [4, p. 78]. It was one of the most effective weapons used by Europeans against the Native Americans and was responsible for the death of a large fraction of the entire North and South American native Indian populations.

In 1798, Edward Jenner, a Scottish physician, discovered that it was possible to immunize, or as he called it, *vaccinate* against smallpox by infecting the patient with the closely related but far less deadly cowpox virus [4 (p. 72), 8 (p. 57)]. Use of the Jenner vaccine was so effective that in 1969 the World Health Organization (WHO) announced its plan to eradicate smallpox from the planet. The last naturally occurring incident was in Somalia. On April 17, 1978 the WHO office in Nairobi, Kenya, sent a telegram

to Geneva which stated that "Maow Maalin is the world's last known smallpox case" [8 (p. 57), 19].

At that time, only three small vials of smallpox virus were believed to remain in existence—one in Atlanta at the Centers for Disease Control, one in Britain, and one in Moscow. There was considerable discussion at the time concerning whether these samples should be destroyed, thereby removing this scourge once and for all from earth. Strong opposition came from environmental groups who objected, in principle, to the intentional elimination of any species, and this objection continued even after the offer was made to decode the *V. major* genome so that in the most unlikely case that it was ever needed in future it could, in principle, be reconstructed.

The American sample remained safely stored; the British experienced some difficulties and a very small release of their virus resulted in several deaths but these were contained and the virus did not spread further. In Moscow, the situation was vastly different. Despite the fact that the Russians had signed the 1972 Biological Weapons Convention along with 141 other nations, Russia undertook a major strategic program (discussed in greater detail below) to develop the smallpox virus as a weapon following some genetic engineering so that existing vaccines for the natural virus would no longer be effective. Then vast quantities of this engineered virus were produced.

6.2. Plague

The next most deadly of the biological agents is plague [7 (p. 5), 6 (p. 122)], which was first described by Homer as a weapon in the Trojan Wars in 1190 BC. The bacterium traveled from Greece back to Rome with members of the Roman legions, resulting in the first European pandemic in which 100 million Europeans died. The second European pandemic, known as the Black Death period from 1346–1352, resulted in the death of 24 million people—25% of the entire European population at the time. By the end of the 14th century, plague had killed 30 million Europeans.

The second specific reported use of plague as a weapon in warfare was in 1346 during the Tartar siege of the city of Kaffa in what is now Crimea.

The third plague pandemic occurred in China beginning in 1894 and 50,000 deaths were recorded in Manchuria alone from 1910 to 1911. In 1898, this Chinese pandemic spread to Bombay where over the next 50 years more than 15 million Indians died; it was in India that the bacterium *Y. pestis* was first identified.

In 1970, analyses by the WHO estimated that if 50 kg of plague bacteria were released upwind of a city of 5 million inhabitants, some 150,000 would develop pneumonic plague, 50,000–100,000 would require hospitalization, and 35,000 would die [4, p. 96].

6.3. Anthrax

The anthrax bacterium occurs naturally in the soil worldwide and can be picked up by grazing animals. In the past, in its cutaneous form, it was relatively common among tanners and those working with raw wool.

It is unique in that when its environment becomes unsatisfactory—usually by becoming too dry—the bacterium converts itself into a hard spore that has been demonstrated to last

for decades, fully viable when the environment becomes attractive to it. In 1940, a British Navy ship fired a few shells containing anthrax spores onto a lonely, totally uninhabited, small island north of the Shetland chain in one of the world's worst weather regions. For various reasons, this island remained untouched and unvisited until 1976 when it was decided to take a second look under the assumption that the anthrax spores would long since have been disabled. On the contrary, it was found that the island was swarming with completely viable anthrax spores after a 36-year interval in terrible climatic conditions. It required 280 tons of formaldehyde and 2000 tons of seawater to disinfect the island [4, p. 57]. It is this spore formation characteristic that makes anthrax an attractive biological weapon agent.

As far as we know, anthrax was first used by the Germans in World War I, not against humans but against horses and cattle [7, p. 69]. Infected animals were introduced into herds of healthy ones, and the disease spread rapidly despite the fact that it is not contagious unless airborne.

The WHO has estimated that if 200 pounds of anthrax spores were released on a clear, calm night upwind of Washington, DC, between 1 and 3 million deaths would result [7, p. 67].

Interest in anthrax was greatly heightened by the attack on political and media leaders in the period following the September 11 attacks, when it was initially assumed that a second terrorist attack was in progress. A number of deaths resulted from inhaling anthrax, a few serious illnesses resulting from gastrointestinal anthrax, and there were numerous cases of the relatively simple cutaneous anthrax—where spores find breaks in the patient's skin and revert to their active bacterial state. At this writing, it has been generally concluded that this anthrax had a domestic source but the perpetrator has not yet been identified.

6.4. Tularemia

Tularemia is caused by the bacterium *Francisella tuluremensis* and is named after the county in California where it was first identified in 1911. It was used in weaponized form by the Russians against the Germans in World War II, and by the Japanese against the Soviets in the 1930s [6, p. 168]. It tends to incapacitate its victims; death, when it occurs, is a consequence of pneumonia, resulting in 2% lethality. Streptomycin and gentomiacin are the best antibiotics, and if administered early in the infection, are completely effective. The WHO has estimated that if 50 kg of tularemia bacteria were released over a city of 5 million, 250,000 would be incapacitated and 19,000 would die [6, p. 168].

Although still available in several countries, tularemia joins a list of other diseases that at one time or another appeared promising as biological weapons but are now less appealing. These include glanders, equine encephalitis, typhus, typhoid, and paratyphoid.

Botulinum toxin is, by many measures, the most poisonous known material. One gram of botulinum toxin, in theory, if released in aerosol form, could kill more than 7 million people, and a tiny droplet on the skin is enough to be lethal [4, p. 106]. It is produced by the bacterium *Clostridium botulinum* and the bacterium is spore forming, like anthrax. The toxin causes paralysis by blocking nervous signals to the muscles and results in death by asphyxiation. It was first used by the Japanese on Chinese prisoners of war in the mid-1930s. Four countries—Iran, Iraq, North Korea and Syria—are currently believed to be developing botulinum toxin as a potential weapon; the Soviet Union devoted a major

effort to it before deciding that more effective biological weapons were available. Fortunately, there is an antitoxin, based on horse serum, that can be effective if used shortly after exposure to the initial toxin.

6.5. Filoviruses

Among the most deadly of the viruses that have been developed and weaponized are the hemorrhagic fevers, best known in the Ebola and Marburg strains. They, as well as the other hemorrhagic fevers, are caused by different filoviruses and, particularly in the case of the Ebola strain, can be 100% lethal [4, p. 114].

The Marburg strain was discovered in Germany in 1967 [4, p. 118], and the Ebola in Zaire in 1976. In an epidemic in Zaire, over 90% of those infected died; in a smaller outbreak in Sudan, only 50% of those infected died. The assumption is that the virus has slightly different variants, much like influenza, that vary in lethality. The *Aum Shinrikyo* cult in Japan tried repeatedly to obtain Ebola virus but did not succeed.

As far as is known at present, there is no treatment for either Ebola or Marburg, nor any vaccine; the only medical intervention is amelioration of the horrible symptoms as the diseases progress.

6.6. Salmonella

A readily available but little used weapon is salmonella, although the variant *Salmonella heidelbergensis* is capable of causing severe illness and death. In 1984, members of the Rajneeshee cult in The Dalles, OR, contaminated the food in a number of salad bars in local restaurants with salmonella as a test exercise to determine whether the resulting incapacitation, if applied on a wide scale, could allow cult members to influence local elections. In the particular test carried out, some 750 people reported illness of varying severity [7, p. 85].

6.7. Engineered biological weapons

The Russians have led the development of hemorrhagic fevers as biological weapons. In 1997, at the Vector installation near Novosibirsk, the Russians succeeded in inserting a gene for Ebola into *vaccenia* while maintaining both viruses in full active form in a single, merged, new virus which, in effect, was a biological super-weapon, with the simultaneous killing characteristics of both smallpox and hemorrhagic fever [16, p. 261].

7. Agroterrorism

All of the above biological weapons are targeted mainly at humans. But effective attacks can also be mounted against the human food chain and against plants and animals, as attempted by the Germans with glanders in World War I.

Among plants, the two most dangerous diseases are rice blast (caused by the fungus *Pyricularia grisea*) and wheat rust (caused by the parasitic fungus *Puccinia graminis*).

In either case, millions of tons of rice and wheat can be eliminated, with serious effect on the food supply in the nation involved, and to other nations to which is might export. Little effort has been devoted to weaponizing anti-plant biological agents, although Russia and the US—the latter while still involved in the development of offensive biological weapons—did have programs for their development.

Diseases affecting animals in the human food chain are widespread around the world, and occasionally cause local epidemics. In 1996, an outbreak of hoof-and-mouth disease in Taiwan resulted in the slaughter of 85 million hogs at an economic loss of $7 billion.

In the 1990s, Britain destroyed 1.35 million cattle at an economic loss of $12 billion in an attempt to limit the spread of the mad cow disease in Britain and into the rest of Europe [4, p. 148]. In Germany and France, millions of cattle were destroyed because of suspected exposure to the mad cow agent.

Mad cow disease (bovine spongiform encephalopathy [BSE]) is believed to be caused by the insecticide Phosmet organophosphate (OP) and hoof-and-mouth disease is caused by *Apthovirus*.

Yet a third potential biological weapon that might be targeted against domestic animals is brucellosis (caused by the bacterium *brucella*), a disease that causes spontaneous abortion [4, p. 140], and thus has the ability to destroy herds of cattle and other animals susceptible to it. Brucellosis is a zoonotic disease, meaning it can be transmitted to humans. Also in this category is listeriosis [4, p. 140], which is caused by the bacterium *Lysteria monocytogenes*. Listeriosis causes severe gastrointestinal symptoms in humans and can be fatal in pregnant women and animals. Both brucellosis and listeriosis have been considered as potential weapons, but only marginally.

8. Development of selected national WMD programs

8.1. The United States

Development of nuclear, chemical, and biological weapons of mass destruction began, in the United States, in 1942 during World War II, when nuclear development was the focus of the Manhattan Project at Los Alamos, and chemical and biological programs were centered in Fort Detrick, MD, both under the general control of the US Army.

Between 1942 and 1948, at least 239 open-air tests of chemical and biological test weapons were conducted across the US, testing the susceptibility of hospitals and other institutions and the effectiveness and sensitivity of detection systems, and in some cases, to exercise all of these with supposedly harmless chemicals and bacteria.

For instance, in 1946, the Navy dropped thousands of pounds of the bacterium *Serratia marcescens*—at the time believed to be totally safe—into the water a few miles offshore of San Francisco [20]. Plates of growth medium were distributed throughout San Francisco so when the *Serratia* bacteria collected on them began to generate their characteristic blood-red exudate, it would be relatively easy to determine the distribution of bacteria throughout the city. There was, at the time, a serious worry that Japan might attempt such an attack with chemical or biological weapons, and the tests were considered essential. Unfortunately, it was subsequently learned that *S. marcescens*, a common bacterium in

the soil, is quite harmless as long as it is exposed to the open air. The moment it is placed in an anoxic environment, however, it becomes exceedingly dangerous and attacks both bone and flesh. In the San Francisco area, *Serratia* test results showed that in the period during which *Serratia* bacteria were blowing across San Francisco, 11 surgical patients in the Stanford Hospital became infected and one patient, Edward J. Nevin died [21]. (The author herein, D.A. Bromley, was one of a small number of individuals who survived a complete systemic infection with *Serratia* acquired during open heart surgery in 1983 in New Haven, CT.)

The US chemical and biological weapon program was relatively short-lived because in 1969 President Nixon announced that the United States was unilaterally withdrawing from the production of offensive chemical and biological weapons and was committed to destroying those that it held in storage. Nixon announced: "I will reaffirm that the United States will never be the first country to use chemical weapons to kill … [or] incapacitate. I have decided that the United States of America will renounce the use of any form of deadly biological weapons that either kill or incapacitate" [9].

This announcement was followed by the 1972 Biological Weapons Convention, which was signed by 142 nations. By 1975, the US Senate had ratified both the Geneva Protocol of 1925 (prohibiting use of poison gas in warfare), and the Biological Weapons Convention of 1972. It bears noting that in 1969, when President Nixon made his declaration, the US had in storage some 40,000 l of anti-personnel weaponry, 5000 kg of anti-plant agents, and 45,000 toxin-coated bullets and *flechettes* (small darts). All were destroyed [15, p. 80].

In July 1996, following the collapse of the Soviet Union, Congress passed the Nunn–Lugar–Domenici Amendment to the Defense Appropriation Act of 1996. This important amendment had three major parts:

- Measures to increase US preparedness to detect and respond to WMD terrorist attacks.
- A package of monetary increases for programs designed to better safeguard supplies of fissile materials and nuclear warheads in the former Soviet Union and to prevent their dispersion to rogue nations elsewhere in the world that might well be expected to use them in support of terrorist activity.
- The establishment of a National Coordinator for Non-Proliferation Matters. The Clinton Administration appointed David Clark to this position.

The amendment made approximately $400 million available for programs to inhibit the dispersal of Soviet nuclear materials and weapons, as well as Soviet nuclear weapons scientists and engineers. Sadly, legal, banking, and bureaucratic details in both the US and Russia, greatly inhibited the delivery of funding to the Soviet scientists and engineers.

A far more successful program that succeeded in getting funds to the appropriate personnel (without having substantial taxes removed by the Russian government and Russian laboratory directors) was organized by the American Physical Society and funded in large measure by a $100 million gift from private investor George Soros.

In 1997, while President of the American Physical Society, one of the authors (DAB) received a communication from an old friend, Nikolai Laverov, a distinguished

geophysicist who was Vice President of the Russian Academy of Sciences and the only member of the Gorbachev *Politbureau* who survived, politically, the end of the Gorbachev regime. It said succinctly: "Dear Allan: I know that you are trying as hard as you can to get critical support to us, but I can only say that by the time it gets here, we will all be dead! Best regards, Nikolai" [22].

8.2. The Japanese program

In 1932, during its war with China, the Japanese established in China the so-called Unit 731 under the command of Major Ishii Shiro [15, p. 76]. Disguised as an Epidemic Prevention and Water Supply Unit, Shiro immediately organized one of, if not the, most inhuman and brutal program of human testing in all history on at least 3000 Chinese, Russian, American, British, and Korean prisoners of war whom he used as guinea pigs. His activities, and those of his colleagues, at times apparently went even beyond the horrors of the Nazi medical experiments. The Japanese tested some 35 different weaponizable bacteria and viruses on the prisoners and on Chinese civilians, including tests to both freeze and cook the prisoners until dead. It is reported that one of Shiro's favorite sports was providing neighborhood children with chocolates laced with anthrax spores.

It is almost conclusive that the Japanese waged biological warfare against China. On November 4, 1941 around 5 a.m., an enemy plane flying low over Changteh in the Hunan Province, dropped wheat and rice grains with pieces of paper and cotton. These were analyzed and found to contain plague bacteria. On November 11, 1941, the first cases of plague appeared [23].

In 1949, a former member of Unit 731 defected to American authorities in Japan. That person noted that after Unit 731 moved to Pingfang, a town near the northeastern city of Harbin, China, and became fully operational, it could produce 300 kg of plague bacteria; 500–600 kg of anthrax spores; 800–900 kg of typhoid, paratyphoid, or dysentery agents; and as much as 1000 kg of cholera germs each month—8 tons of bacteria a month, by a 1949 Russian estimate [23]. In August 1945, the Pingfang operation was destroyed by the Japanese as the Russian army approached.

8.3. Soviet (and later Russian) programs

Very little was known in the West about any Russian program prior to the late 1980s, and it was generally assumed that the Russians, like Britain and the US, had simply put their sample of smallpox virus into secure storage.

The first hint that the Soviets might be violating the 1972 Biological Weapon Convention came in 1979, when through various channels, it was learned that there had been an accident in the Russian city, Sverdlovsk, and that a number of local citizens had come down with human pulmonary anthrax, a deadly disease. Information indicating that the Soviets were working with weaponized anthrax spore aerosols accumulated, and in 1980, the US formally asked the Russians to explain this apparent violation of the 1972 Biological Weapons Convention [15, p. 68]. The Russians insisted that the cases of pulmonary anthrax resulted from consumption of anthrax-contaminated meat purchased on the black market, and repeated this explanation on

several occasions and in several forums. It was not until 1992, during a visit to the United States, that Russian President Boris Yeltsin admitted, "there has been a lag in implementation of the Biological Weapon Convention" in the Soviet Union and in Russia. It was further discovered that the Sverdlovsk accident involved the failure to replace a key filter and that led to release of substantial amounts of anthrax spore aerosol into the atmosphere. As was learned subsequently, the Soviet military was exceedingly unhappy about these disclosures and admissions and attempted to minimize their diffusion to the world community.

The first real break in the Soviet wall of secrecy around its WMD and, in particular its biological weapons program, came in 1989 when Vladimir Pasechnik, a 53-year-old chemist who had been director of the St Petersburg Institute for Ultra-pure Biopreparations, defected to the British. Among his first remarks was: "I am part of Biopreparat, a large, secret program which is involved in scientific research, development and production of biological weapons throughout the USSR" [8, p. 84]. This was the first indication, in October 1989, in the West, of the existence of the huge Biopreparat industrial-scale activity—in violation of the 1972 Biological Weapons Convention—which was functioning in the Soviet Union. Pasechnik reported that the Soviet Union had multi-ton stocks of frozen plague bacteria, smallpox virus, and a variety of other weaponized material waiting for insertion into intercontinental and intermediate-range missiles. He also reported that the smallpox virus in these warheads had been genetically modified to render the original smallpox vaccines ineffective; also that the plague bacteria had been modified so they were resistant to any available antibiotic. Britain kept Pasechnik under wraps until late Spring 1990 when, under heavy CIA pressure, he was brought to the US It quickly became apparent that because of the closedown of the American program in 1969 no one in the US government could properly interrogate Pasechnik [8, p. 86]. The US lack of knowledge of the Soviet program and its lack of reaction to the Pasechnik revelations were little short of astonishing.

In Spring 1991, after President Ronald Reagan and Prime Minister Margaret Thatcher had been briefed on the Pasechnik revelations, Thatcher called President Gorbachev and demanded that the Russians open the Biopreparat program to inspection by a joint British–American team [8, p. 88]. It was immediately obvious to the inspectors that the Russians had in place a major strategic program parallel in scope to their already substantial program of nuclear weaponry. The leader of the British component of the inspection team, Christopher Davis, summarized the situation during the inspections as follows: "This was clearly the most successful biological weapon program on earth. Yet these people just sat there and lied to us, and lied, and lied" [8, p. 89]. To this day, we still do not know many of the pertinent details of what happened to the military facilities that were at the heart of this Russian program of biological weaponry.

The situation became somewhat clearer in 1992 when Kanatian Alibekov (now known as Ken Alibek) defected to the United States [16, p. 257]. Alibek holds a PhD and DSc in microbiology and biotechnology, respectively, and became known in his organization for his successes in developing superior production technologies for anthrax spores in aerosol form. He joined Biopreparat in 1975 and was its first Deputy Chief from 1988 to 1992 when he defected. On his arrival in the US, the CIA found it

necessary to recruit William C. Patrick from retirement in order to obtain the maximum information from Alibek. Patrick had been head of the American program prior to 1969 and his discussions with Alibek provided an enormous amount of new data [8, p. 188]. Aware that this long-secret information was becoming more public, in 1994 the Russians admitted that they were working with smallpox, plague, anthrax, botulism, tularemia, glanders, typhus, Venezuelan equine encephalitis, and Ebola and Marburg hemorrhagic filoviruses.

In 1999, Alibek published a book entitled *Biohazard* in which he described the Russian program in detail. It should have provided a major wake-up call to the entire Western world, but unfortunately there was little publicity, and relatively few people read the book. Among Alibek's major revelations are the following:

- In 1928, the Revolutionary Military Council in the Soviet Union signed a secret decree ordering the transformation of typhus into a biological weapon. This began the Russian biological warfare program long before any other one on earth [16, p. 23].
- By 1930, the Leningrad Academy had produced powdered and liquid versions of typhus for preparation as a primitive aerosol. It had been discovered that the aerosol particles had to be in the range of 1–10 μm in diameter because if larger they did not penetrate deeply enough into the lungs and if smaller they were promptly exhaled [16, p. 24].
- Beginning during World War II, the Soviets maintained a 20-ton supply of plague bacteria in the city of Kirov.
- In 1947, the Russians began working with smallpox and undertook, through crude genetic engineering and other changes, to produce a more lethal smallpox virus that was unaffected by existing vaccines [16, p. 111].
- In 1970, the Soviets had built up a stockpile of 20 tons of smallpox virus [16, p. 112].
- In 1987, the Russians were producing up to 5000 tons of anthrax spores per year [16, p. 99].
- In October 1989, Alibek first learned of Pasechnik's defection to the British [16, p. 138].
- Shortly before Alibek defected, the Russians had developed a new technology to replace grinding, which had been used up to that time to produce appropriate size particles from evaporated liquid materials containing weapons bacteria and viruses. This involved a powerful blast of air directed on sheets of the evaporated liquid which produced a powder of precisely the right size range, and vastly increased the productivity of the system [16, p. 261].

With the collapse of the Soviet Union, the relatively simple portability of these biological weapons and today's burgeoning terrorist market for them, poses a serious problem for the US and its allies.

To focus on this question of rogue nations and their possible support of terrorism, Congress formed the Commission to Combat the Proliferation of WMD, chaired by John Deutsch, former Provost of MIT and then-Director of the CIA. The Commission's report identified Cuba, Iran, Iraq, Libya, North Korea, Sudan, and Syria as nations actively seeking to develop WMD capability [7, p. 50].

9. Characteristics of WMD terrorist attacks

A simple nuclear explosion creates destruction through physical blast, neutrons, and gamma rays (very high-energy X-rays); also by infrared, optical, and ultraviolet radiation; then followed by fallout containing radioactive species produced in the initial explosion, which interact with the immediate environment. Given modern detection technology, nuclear, radiological, and chemical attacks would be expected to be recognized immediately and, depending on the size and nature of the weapon and the effectiveness of the delivery technology used, the size of the affected area would quickly be determined. The center of impact would be clearly evident, and the damage and injury relatively localized around that center, leaving no uncertainty as to where response activities were needed. This also would be true for any attack involving chemical weapons.

In the case of nuclear weapons [24], the blast destruction of buildings for miles around the center of the attack would fill the streets to a level of many feet with debris. Thus medical help simply cannot become immediately available to those who survive the initial blast and radiation. Thousands, perhaps millions, of people will suffer major burns. Today's hospitals—under pressure to become more efficient—typically have few beds available for such surge emergencies. A check of the number of beds in the New York suburbs available for burn victims found only a few score unoccupied at the time of the study. In such a nuclear attack, no medical care would be available except for those in the extreme periphery of the impact zone.

In the case of chemical weapons, transportation facilities would remain operable, and patients could be transported to medical facilities, although these would very quickly become saturated. All of the tests conducted thus far with simulated WMD attacks have demonstrated conclusively that the US is totally unprepared to respond to the medical needs of the survivors of such attacks.

In the case of biological weaponry, the situation is vastly more serious, particularly in the case of smallpox, which has a latency period of 12–14 days during which the infected patient is contagious and can infect those in his or her vicinity. A typical multiplication factor, derived from the 1976 Mechede event [8 (p. 46), 25], is 17, but that number can range from 10 to 20. Thus, it will not be obvious that a region has been attacked, or from where the attack originated, because the virus remains effectively silent during the latency period during which the originally infected individual may move over long distances.

For individuals or small group terrorists, one of the attractions of anthrax or plague is the relative ease with which substantial quantities of the agent can be grown in a liquid growth medium, by spreading that medium on a flat surface, allowing the liquid component to evaporate, and then milling the resulting dry residue containing the anthrax spores or plague bacteria into particles of an appropriate size. Modern crop-dusting technology offers a convenient method for dispersing such agents over a target zone.

Given today's worldwide air transportation, during the incubation period the disease could be spread worldwide and the number of infected persons grow exponentially. In the belief that smallpox had been eradicated worldwide, in 1972 the WHO recommended that smallpox vaccinations cease. Therefore, today all those who were vaccinated prior to 1972 are effectively no longer protected, in addition to everyone after 1972 who lack any vaccination. Even worse, the smallpox used in an attack may be unaffected by any of

the old vaccines because of the new smallpox variant has been genetically modified, thereby having the potential for a disaster beyond any the human race has ever experienced, one that could in principle eliminate a significant fraction of the earth's population. The consequences of an attack with a merged Ebola/smallpox virus is beyond imagining.

10. Response to WMD terrorist attacks

There is a well-substantiated consensus that the United States is poorly prepared to respond to a WMD terrorist attack, particularly one involving biological weapons.

In 2001, the US military organized a test called 'Dark Winter' [4, p. 166], a simulated smallpox attack that began with 20 (theoretical) confirmed cases in Oklahoma City. As the exercise evolved over two weeks, 16,000 cases were estimated in 25 states, and 1000 deaths occurred. In another three weeks, 300,000 cases were estimated and 100,000 deaths. In one month following initiation of the exercise, three million cases were estimated with one million deaths. And the 'Dark Winter' test premises totally ignored the fact that during the exercise period, there would have been massive dispersion of smallpox from the US throughout the world.

In a second exercise in 2002 in San Antonio, TX, supported by the US military, the 'Pale Horse' exercise [26], a new focus was introduced: some of the legal and constitutional questions that such an attack would raise were discussed. Again, the results showed that the country was remarkably ill-prepared to respond, particularly with respect to legal requirements for informed consent prior to the use of a new smallpox vaccine, an investigational new drug at the time.

While it would be difficult for would-be terrorists acting alone to acquire the smallpox virus, there are literally dozens of laboratory supply outlets in the US that could, until 2003, provide all of the above-mentioned weapon species and many more via mail, e-mail or telephone, with essentially no check on the intended recipient. Regulations to monitor the registration of 'select agents' [27] when mailed or transported were promulgated in 1997 [28]. The Public Health Security and Bioterrorism Preparedness and Response Act of 2002, enacted on June 12, 2002, resulted in regulations that became effective on February 7, 2003 [29]. In addition to registration for transport and possession, the new regulations require registration of those who contact the select agent, security plans, and registration of those handling any select agent(s).

Major legal questions arose over issues of quarantine and containment. In the original WHO program to eliminate smallpox, the technology of 'ring' vaccination was found to be remarkably effective [4, p. 158]. In this program, whenever a case of smallpox was reported, the WHO agents immediately undertook a 100% vaccination of all persons in a ring surrounding the original case, thus preventing the spread, particularly in cases in the developing world where it was possible to contain the population within the ring given the absence of air and other major travel possibilities. Although it has been suggested that the ring technology could be used as part of an American response to a biological warfare attack, major problems arise in balancing the need for quarantine and containment with the individual freedoms and civil rights that Americans have come to expect within the rule of

law in the United States. For example, each American has the constitutional right to have an individual judicial hearing before he or she can be quarantined or contained. Obviously, this situation would be untenable in an actual attack scenario in a large office building, school, or sports arena where 50,000 or more individuals would have the right to demand individual hearings.

It is also true that *Posse Comitatus* laws, dating from the period following the Civil War and designed to prevent the use of military force to suppress civil disorder in the South, are still in force, and they make it impossible for the military to participate in civilian activities, as for example, in responding to a terrorist attack, unless requested by the governor of the state involved, and unless the President determines that an emergency situation requires military intervention.

Obviously, the constitutionally guaranteed right of privacy [30] enjoyed by Americans would necessarily come into conflict with any effort at quarantine or containment. This is a simple example of the fact that under conditions that held until very recently, cooperation between federal, state, and local governments has been extraordinarily informal and haphazard. This became clear in the anthrax attacks of 2001, where the FBI was officially the lead agency, but it had no expertise whatever in biological weaponry yet was very reluctant to call in the CDC or the US Public Health Service for assistance. In the early days of the anthrax attacks, the FBI authorized the destruction of a library of over 100 different strains of anthrax, assembled over decades at the University of Iowa, which would have been enormously helpful for identifying the particular strain involved in the US attacks.

Despite assurances from the Department of Health and Human Services (DHHS) concerning the then 12 major depositories of medications that have been developed under the National Pharmaceutical Stockpile Program (NPSP) so that within 12 h they can be rushed to any part of the United States [4, p. 114], it is increasingly clear that this will be woefully inadequate, and that the country must be prepared for surge demands on its medical facilities and on supplies of appropriate medication far beyond any current capability. The shared responsibilities between state and national governments have been left as a mere coordination function staff line to the Secretary of Homeland Security. This federal government to state government relationship must be examined and defined so that there are no questions of leadership and responsibility when confronting any threat against homeland security.

Fortunately, President Bush and his administration recognize many of these problems, as well as those requiring more effective monitoring and closure of the nation's borders against potential terrorists and potential terrorist weapons. The Office of Homeland Security, within the Executive Office of the President was created first, followed in 2002, by the Homeland Security Act of 2002 which, when fully implemented, will bring the most dramatic reorganization of our federal government in the nation's history. However, an enormously complex task lies ahead as the country comes to grip with devising adequate responses to a WMD attack. The presence and possible use of WMD means that society must recognize it is in a completely new era, and everyone must face up to some extraordinarily difficult decisions—before the need for such decisions is forced upon us all.

11. Uncited references

[1–3].

References

[1] Alibek K. Biohazard. New York: Random House; 1999 [A detailed description and discussion of the Soviet Union, and later Russian, Biopreparat program, of which Alibek was first Deputy Chief, from 1988–1992. This is a uniquely valuable insight into what, for much of the 20th century, was a totally secret Soviet and Russian initiative].

[2] Cohen BL. Before it's too late. New York: Plenum Press; 1983 [This is one of, if not indeed the best, overall treatment of the effects of radiation on living systems, and provides a lucid description of the relative risks attached to activities in which the typical American citizen is involved].

[3] Falkenrath RA, Newman RD, Thayer BA. In: Falkenrath Richard A, editor. America's Achilles heel. Cambridge, MA: MIT Press; 2001 [This is a fact-filled volume treating all weapons of mass destruction as one group—nuclear, biological and chemical terrorism. Science and technology, as well as a discussion of the covert attack methods and technologies that might be anticipated is also included].

[4] Frist B. When every moment counts. Totawa, NY: Rowman and Littlefield; 2002 p. 129 [This is a volume written by the current leader of the US Senate, and a pediatric cardiologist, designed for the general public, and discussing the nature of a wide variety of biological weapons and the typical response to them].

[5] Garwin RL, Charpak G. Megawatts and Megatons. New York: Knopf; 2001 p. 59 [This is by far the best overview of the current status of our military and civilian use of nuclear energy, written by two internationally recognized experts and written at a level available to any member of an interested public].

[6] Henderson DA, Inglesby TP, O'Toole T. Bioterrorism.: AMA Press; 2002 p. 23 [This is a collection of 15 essays by some of the nation's most prominent experts in the bioterrorism field, covering a great many aspects of the nature of bioterrorism attacks and our possible response to them].

[7] Osterhold MT, Schwartz J. Living terrors. New York, NY: Delta; 2001 p. 14 [A book designed for the general public, based on several possible scenarios each of which is presented and discussed in detail].

[8] Preston R. The demon in the freezer. New York: Random House; 2002 p. 92 [A detailed history of the World Health Organization program to eliminate smallpox. Preston is also the author of *The Hot Zone* and *The Cobra Event*, the latter book being one that stimulated President Clinton to begin mobilization of a response to potential bioterrorist attacks].

[9] Sutton VV. Law and bioterrorism.: Carolina Academic Press; 2002 p. 279 [This is the first book that examines the impact that potential bioterrorism attacks will necessarily have on the theory and practice of law in the United States].

[10] Presidential Decision Directives Nos. 39 and 62 were issued by President Clinton and are classified, but have been redacted. They designate the FBI as the lead agency in the investigation of suspected incidents of bioterrorism.

[11] *United States v. Lopez*. 514 US 549; 1995.

[12] Private communication to D.A. Bromley from Yuri Ossipyan, former Science Advisor to President Gorbachev of the Soviet Union.

[13] In addition to a multiple number of independently targetable warheads, missile technology had advanced to the point where it was also possible for the bus missile to carry either a single massive warhead with hundreds of kilograms of biological agent or one hundred or more 'bomblets,' each equipped with its own shield to protect it during re-entry. These bomblets then scatter over a wide target area before releasing their biological agents.

[14] Zajtchuk, editor. Textbook of military medicine. Office of the Surgeon General; 1997. p. 10.

[15] Falkenrath RA, Newman RD, Thayer BA. America's Achilles' hell: nuclear, biological, and chemical terrorism and covert attack.: MIT Press; 1998 p. 226, 256.

[16] Alibek, Handelman. Biohazard: the chilling true story of the largest covert biological weapons program in the world. New York: Random House; 1999 p. 278.

[17] The most famous assassination with ricin was that of Bulgarian dissident Georgi Markov in London in 1978, when he was stabbed in the thigh with an umbrella tip containing a pellet of ricin. See: Mangold T, Goldberg J. Plague wars, the terrifying reality of biological warfare. New York: St Martin's Griffin; 1999.
[18] Private communication to D.A. Bromley from Jay Davis; 1999.
[19] Tucker JB. Scourge—the once and future threat of smallpox. New York: Atlantic Monthly Press 2001 p. 118.
[20] Private communication to D.A. Bromley from Irving Polayes; 1983Miller J, Engelberg S, Broad W. Biological weapons and America's secret war, germs.: Simon & Schuster; 2001 p. 42.
[21] Cole LA. Clouds of secrecy: the army's germ warfare tests over populated areas. Totowa, NY: Rowman and Littlefield; 1988 p. 75–104.
[22] Private communication to D.A. Bromley from Nikolai Laverov; 1997.
[23] Harris R, Paxman J. A higher form of killing. New York: Random House; 2002 p. 82.
[24] The effects of nuclear war: a report from the Office of Technology Assessment; 1979.
[25] The Meschede Event: an outbreak in Meschede, West Germany occurred in late 1970 when a West German electrician returning from Pakistan was hospitalized in a private room on the ground floor of the Meschede Hospital and was isolated in that room. Over the next weeks, 19 cases of smallpox developed in the hospital, although only two nurses had physical contact with the patient. Subsequent tests with smoke-produced soot whose particles had roughly the same dimension as the smallpox virus demonstrated that both could and did seep through supposedly closed windows and up the side of the hospital, where the entered through, again, supposedly closed windows into rooms on both the second and third floors. It was this event that gave the frequently used multiplication factor of 17 for smallpox infection.
[27] One of the authors, Victoria Sutton, chaired the legal section of the 'Pale Horse' exercise.
[27] 'Select Agents' is a artful term to describe a list of biological agents that are regulated by the federal government.
[28] CFR. §12; 2003.
[29] CFR. §13; 2003.
[30] The 'right of privacy' was first articulated by the US Supreme Court as a fundamental constitutional right in Griswold v. Connecticut, 381 US 479; 1965.

Victoria Sutton is Director of the Center for Biodefense, Law and Public Policy and Professor of Law at Texas Tech University School of Law. She holds Bachelor of Science degrees in Zoology and Animal Science *cum laude*, from North Carolina State University; a Master's degree in Public Administration from Old Dominion University; a PhD in Environmental Sciences from The University of Texas at Dallas; and a Law degree (JD) from American University, *magna cum laude*. She served as Assistant Director in the Bush Administration from 1989 to 1993 in the Office of Science and Technology Policy in the White House Science Office, and in the US Environmental Protection Agency. Dr Sutton is a member of the District of Columbia Bar and the US Federal Circuit Bar. She is the author of four books and numerous articles. Her awards include the 2003 Texas Tech University Book Award for Law and Science: Cases and Materials.

D. Allan Bromley (deceased February 2005) was the former Assistant to the President for Science and Technology and Director of the Bush Administration's Office of Science and Technology Policy. Following this term, he was Dean of Engineering and the Sterling Professor of the Sciences, Yale University. Dr Bromley was the author of over 500 peer-reviewed articles and 20 books; he held 33 honorary degrees; and he was the recipient of the National Medal of Science, the highest honor bestowed on a scientist in the United States. He was also the recipient of the 2002 Nicholson Prize for lifetime achievement in the sciences.