

## **The Dark Side of High Technology: Weapons of Mass Destruction**

The only potential ethical issues associated with strictly scientific pursuits concern the publication of information known to be inaccurate or known to be plagiarized from the work of others. Technology, however, can be used for both moral and immoral purposes.

The fruits of essentially every form of technology have been used for lethal purposes throughout recorded history. The following will discuss several relatively recent technological developments that have been used to incapacitate or kill other organisms or other humans. Because the morality of some of these specific uses of technological developments are matters of disagreement, most of the following discussion will be confined to a presentation of the history and the functional principles of the technologies involved. Evaluation of the relative morality of the application of these technologies is left to the reader.

The US government has described some weapons as being capable of inflicting very large numbers of casualties – as being capable of the “mass destruction” of lives or property. These weapons fall into three major classes: nuclear weapons, chemical weapons, and biological weapons.

### **Nuclear weapons**

Nuclear weapons are not based on biotechnology. The discussion of this type of weapon will therefore be brief, and will tend to focus on some popular misconceptions of radiation.

All types of nuclear weapons depend on the release of energy from an alteration in an atomic nucleus. These alterations can be the result of classical radioactive decay, in which the nucleus of the unstable isotope releases an  $\alpha$ -particle (a helium nucleus, a  $\beta$ -particle (an electron or antielectron) or  $\gamma$ -radiation. Alternatively, the alteration can be due to fission of the nucleus (a process that occurs only in very large nuclei) or the result of fusion of two nuclei. Spontaneous nuclear reactions release vastly greater amounts of energy than is released in chemical reactions involving comparable numbers of atoms.



The term “nuclear weapon” is most commonly used to refer to weapons designed to rapidly release massive amounts of energy as a result of uncontrolled fission chain reactions<sup>1</sup> (a process that can, in thermonuclear weapons, be used to trigger further energy release from the fusion of the hydrogen isotopes tritium and deuterium). Fission-based weapons derive their destructive power from a combination of the

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<sup>1</sup> The term “uncontrolled fission chain reactions” is used to differentiate fission-based explosive devices from controlled nuclear reactors, in which the heat released is used to generate steam for propulsion or for electricity generation.

large amount of energy released, the rapidity with which the energy is released<sup>2</sup>, and the fact that some of the energy is released in the form of ionizing radiation.

The term “radiation” refers to the transfer of energy through space. The energy transferred may be the result of a nuclear reaction, or (as in the case of artificial lighting, for example) the result of processes that do not involve the atomic nucleus. Thus, “radiation” is not always synonymous with “radioactive”. Although the intense electromagnetic radiation emitted by lasers or defective microwave ovens may be hazardous, the radiation associated with these devices is not ionizing. Ionizing radiation is radiation that is capable of damaging the covalent structure of biological molecules. The deleterious effects of ionizing radiation are due to aberrant repair of damaged tissue and to damage to the DNA of rapidly growing tissues (especially the tissues of the bone marrow and digestive tract). Most, although not all, radioactive decay processes involve the release of ionizing radiation.



Fission-based devices have been used as weapons twice, during August of 1945. The cities of Hiroshima and Nagasaki were devastated by single weapons based on fission chain reactions using  $^{235}\text{U}$  (Hiroshima) and  $^{239}\text{Pu}$  (Nagasaki). The uncontrolled nuclear reactions essentially obliterated every structure within a 750 meter radius around the spot immediately under the devices, killing everyone within 100 meters, and about 50% of those within one kilometer. Most of the immediate casualties were the result of heat and electromagnetic radiation released by the weapons; these weapons resulted in a larger number of deaths due to the release of large amounts of ionizing radiation and neutrons.

Thermonuclear explosions are the most destructive force known (note that supernovae are based on thermonuclear processes). With the exception of the impact of an asteroid or comet, thermonuclear devices are the only known mechanism for eradicating all known life.

While the hazards of radiation and radioactivity are frequently overstated, distribution of radioisotopes has been proposed as a possible weapon. While  $^{14}\text{C}$  and some other unstable isotopes are naturally present in the environment, some radioisotopes are especially toxic. The toxicity of radioisotopes is due to a combination of the chemical properties of the isotope (isotopes that are concentrated in specific tissues are more likely to be toxic), the half-life of the isotope (only isotopes with half-lives of months or a few years are likely to emit radiation in amounts large enough to be a problem – the radioactivity of  $^{238}\text{U}$ , with a half-life of  $4.5 \times 10^9$  years, is not likely to do much direct damage), and of the energy of the ionizing radiation associated with the isotope. For example,  $^{90}\text{Sr}$  has a half-life of 27 years, and is concentrated in the bones where its radiation damages the tissues that

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<sup>2</sup> The fact that more than mere release of large amounts of energy is required for mass destruction is apparent in that the Space Shuttle uses an amount of energy equivalent to a low yield fission device to reach orbit without inflicting massive damage on its surroundings. Even in the *Challenger* disaster, some of the astronauts are reported to have survived the explosion, which would not have happened had the energy release occurred on the microsecond timescale of an uncontrolled fission chain reaction.



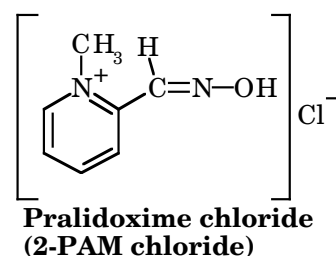
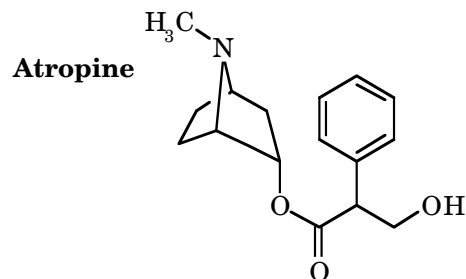
These compounds are called nerve gasses, because they inhibit acetyl cholinesterase, the enzyme that inactivates the neurotransmitter acetylcholine. These compounds are especially lethal when inhaled; in addition, they are lethal if absorbed through the skin (although the amounts required are somewhat larger than the amount required via inhalation).

Following the end of World War I, use of chemical agents became relatively rare. During World War II, chemical weapons were only used intentionally by Japan against China. However, all of the major combatants had considerable amounts of chemical weapons available. The Allies suffered several hundred casualties when the sinking of the supply ship *John Harvey* by a German air strike against Bari harbor in Italy resulted in the release of tons of nitrogen mustard.

Since World War II, several countries have been accused of using chemical weapons. While many of these alleged cases may have been rumors or propaganda, Iranian chemical weapons casualties were treated in European hospitals during the Iran-Iraq war. Finally, a terrorist group used sarin twice in Japan in 1994 and 1995.

Chemical weapons are associated with fear and revulsion. However, chemical weapons are not especially lethal. In World War I, chemical weapons caused about 1.3 million casualties, but only about 91,000 of those soldiers died. By comparison, high explosive weapons caused about 30 million casualties, killing over 8 million. During the terrorist incidents in Japan, four died in the first attack and 12 in the second, although several thousand individuals required treatment for the effects. In general, chemical weapons are associated with a 3% to 5% fatality rate, compared to the 20% to 40% fatality rate associated with the use of “conventional” projectile weapons.

Nerve agents are considered to be the most likely of the chemical agents to inflict mass casualties, especially on unprepared population centers. The likelihood of mass casualties depends on the distribution method for the agent used; the inefficient distribution method used was part of the reason for the low fatality rates in the incidents in Japan. If used against well-equipped troops, these agents are less likely to inflict many fatalities, because most armies supply their soldiers with both protective suits and with antidotes for the nerve agents. One antidote is **atropine**, an acetylcholine receptor antagonist, which attenuates the effect of the accumulation of acetylcholine. Another antidote is **pralidoxime chloride**, a compound that reactivates acetyl cholinesterase. Prompt treatment using a combination of appropriate antidotes and artificial respiration is associated with significant survival rates.



## Biological weapons

Three classes of biological weapons have been proposed: biologically produced **toxins** such as ricin or botulinum toxin, **non-contagious pathogenic organisms**, and **contagious pathogens**.

### Historical aspects of biological weapons

Throughout human history, infectious disease has been a major killer. It was only in the 20<sup>th</sup> century, and even then only in developed countries, that infectious disease was replaced by heart disease and cancer as the leading cause of death. The Second World War was the first major war in history in which death in combat was more common than death as a result of disease.



Probably the first recorded use of biological weapons occurred in 184 B.C. when Hannibal's men catapulted clay pots filled with poisonous snakes onto enemy ships. Hannibal's forces won that battle, although it is not clear whether the snakes played a decisive part.

The use of infectious disease agents as weapons was hampered by a poor understanding of the mechanism of infection. Many attempts were made to spread disease, although it is unclear whether the attempts actually played a role in causing casualties. In addition, spreading disease caused potential problems, because it was sometimes impossible to limit the number of individuals affected by the disease. In 1346, Tartars besieging Caffa (the city located in the Crimea currently called Feodosyia) catapulted victims of bubonic plague into the city. If the plague victims were dead at the time of their placement in the catapult, this would have been unlikely to have had an effect. However, although the mechanism is unclear, the plague entered the city. The defending troops retreated due to the disease, and took the epidemic with them from city to city along the coast. Caffa seems to have been the starting point of an epidemic that killed at least 25 million people (about 30% of the population) in Europe over the next five years.

Pizarro probably gave "gifts" of blankets or clothing containing smallpox virus to the Incas in the 16<sup>th</sup> century. Again, it is not clear whether the "gifts" had an effect; however, whether the disease was spread by intentional or by natural processes, the Incas suffered a major smallpox epidemic that was crucial to the destruction of the Inca Empire. The use of smallpox-infested blankets may have been used by the British in the attack on the French Fort Carillon during the Seven Years War, by the British against the Continental Army during the American Revolution, and by US troops against the Native American tribes during the 1800s. Prior to late 19<sup>th</sup> century, these methods were not very useful, due to lack of understanding of infectious disease. For example, the blankets from yellow fever patients were used to attempt to spread yellow fever; however, this is now known to have been totally ineffective, because yellow fever can only be spread by mosquitoes.

As infectious disease became better understood, several countries carried out research programs in an attempt to develop weapons. For example, Unit 731 of the

Japanese Imperial Army carried out biological warfare experiments using prisoners of war from 1932 to 1945. The British experimented with anthrax during World War II; Gruinard Island near Scotland was contaminated with anthrax spores for years after the war.

Actual use of biological weapons seems to have been fairly rare. Allegations of biological attacks were made periodically during the Second World War and the Korean War. For example, North Korea accused the US of launching biological attacks. The agents available at the time are indistinguishable from natural pathogens; the lack of evidence of an intentional use of biological weapons has led most historians to suspect that the allegations were propaganda based on naturally occurring epidemics.

There are a few well-documented cases of biological weapons use. Two of these seem to come straight from the movies. Soviet defector Georgi Markov was assassinated and defector Vladimir Kostov was nearly assassinated by pellets shot from James Bond-type umbrella guns; the pellets fired contained ricin toxin. More recently, the US mail system was used to distribute anthrax by an as yet unidentified terrorist.

In 1972 most countries signed the “Convention on the prohibition of the development, production, and stockpiling of bacteriological<sup>3</sup> (biological) and toxin weapons and on their destruction.” In spite of signing this treaty the Soviet Union is known to have continued their research into biological weapons. In 1979, an explosion occurred at the Soviet Institute of Microbiology and Virology in the city of Sverdlovsk, and about 70 citizens of Sverdlovsk subsequently died of inhalational anthrax, although the Soviets denied that biological weapons were involved. Following the fall of the Soviet Union, the Russian government admitted that the anthrax release was due to an accident at a biological weapons plant.

The US pledged not to develop, stockpile, or produce biological weapons in 1969. Suspicions that other countries were developing biological weapons led to the establishment of the US Army Medical Research Institute of Infectious Diseases (USAMRIID) in 1969 to develop defenses against naturally occurring and weapons-based diseases. This agency faced potential combat conditions during the 1991 Gulf War. Intelligence obtained after the war indicated that, in addition to stocks of chemical weapons, Iraq had 25 biological SCUD missile warheads (containing anthrax, botulinum toxin, or aflatoxin), as well as bombs and artillery shells with biological weapons warheads. It is thought that the biological weapons were not used, although some evidence suggests that about 20,000 Allied troops may have been exposed intentionally or accidentally to chemical weapons.

In addition to biological weapons intended to act against humans, a possible use of biological weapons is to damage the agriculture of the enemy country. During WWII the US considered releasing a fungus capable of destroying Japanese rice production. This plan was not implemented due to the length of time required for the loss of the rice crop to have an effect. More recently, some evidence suggests

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<sup>3</sup> The treaty was an expansion of the 1925 Geneva Protocol; in 1925, viruses were poorly understood, and infectious diseases were thought to be largely bacteriological in origin. “Bacteriological” became a synonym for “biological”.

that Mediterranean fly problems in California may be the result of intentional release of the fruit fly by terrorist groups.

### **Producing a biological weapon**

Although a number of toxins and pathogens are known, not all of these can be used as weapons. A candidate for a weapon should exhibit several properties. It must be possible to produce the pathogen in large amounts. The pathogen must have significant health effects on the target population, preferably in small amounts, so that the weapon can be transported readily. The pathogen should be stable, especially during storage. It may be useful for the pathogen to be stable following release into the environment, although this increases the probability that the user may become affected by the pathogen some time after release. Finally, it must be possible to “weaponize” the pathogen; weaponization involves converting the pathogen from the form that is grown in culture to a form that can be distributed for maximal effect.

For an organized army, a short incubation time before development of overt disease is useful for directly influencing combat. For a terrorist, a longer incubation time is likely to be preferable, especially if the hosts become infectious prior to becoming symptomatic, because this would allow the hosts to spread the disease and potentially initiate an epidemic.

Some biological weapons are active as a result of inhalation. While this generally means that gas masks are effective preventative measures, it also means that casualties tend to be much more likely to be readily produced. Some biological agents are active when ingested; in developed countries, these are much less useful because water purification methods and food preparation methods tend to inactivate many pathogens.

No known biological agents are absorbed through intact skin, although several may enter through cuts. These agents are less likely to cause large numbers of casualties. Injection of biological agents has actually been used; this method is probably only capable of causing casualties as a result of direct contact between the assassin and the victim.

Finally, a number of possible biological agents can affect crops. This form of attack is unlikely to cause many casualties in developed countries due to the wide variety of different crops in common use; however, an attack on the food supply could be devastating in many underdeveloped countries where single staple foods provide the majority of the calories for the population.

The effects of a biological attack are difficult to predict. The effects depend on the amount of the agent released, on the amount of the agent to which a potential victim is exposed, and on the countermeasures used by the intended victims. In addition, weather tends to affect the results; sunlight contains ultraviolet light that kills many exposed microorganisms, and wind and rain may limit the spread of airborne pathogens.

## Examples of organisms proposed for use as weapons

### Anthrax

Anthrax is caused by the spore-forming bacterium *Bacillus anthracis*. Anthrax is the first disease that was traced to a bacterial origin (by Koch in 1876). *B. anthracis* infects farm animals; when the animals die, the bacteria form spores that are extremely stable in the environment. Farm workers working in small rooms (especially sheepshearers working in small sheds) would occasionally develop the disease (leading to the name wool-sorters' disease).

When *B. anthracis* spores enter the human body through the skin, the bacteria cause a local infection, known as **cutaneous anthrax**, which is rarely lethal. However, if the spores are ingested, the resulting **gastrointestinal anthrax** has a 50% mortality rate, and **inhalational anthrax** is historically almost uniformly fatal. However, although dangerous, anthrax is not contagious.

Most naturally occurring strains of *Bacillus anthracis* contain at least one plasmid. One of these plasmids contains genes that are required for the synthesis of a capsule. During the normal course of anthrax infection, the spores are recognized as foreign, and are engulfed by macrophages; the capsule is required for survival and growth inside the macrophage, and is therefore required for pathogenicity. Another plasmid contains genes for **Lethal Factor** and **Edemia Factor** proteins. The role of these proteins is under investigation, although it is known that Edema Factor is an adenylyl cyclase. The Lethal Factor and Edema Factor proteins enter cells via the mediation of a third protein called **Protective Antigen** (the name refers to the use of purified Protective Antigen as a vaccine to protect against anthrax). *B. anthracis* lacking either of these plasmids is non-pathogenic.

*Bacillus anthracis* can be readily grown in culture. Weaponization requires converting the bacterial culture into spores. Moreover, the spores must be converted into particles of an appropriate size (1 to 5  $\mu\text{m}$  diameter); particles that are too large will not form an effective aerosol, and particles that are too small will not remain in the lungs. Weaponization of anthrax therefore requires some degree of expertise.

The recent anthrax attack in the US used letters contaminated with anthrax spores. Although the spores had apparently been weaponized in a sophisticated laboratory, a relatively small number of people were infected. The low number of casualties was probably due to the inefficient distribution method used; had the spores been spread as an aerosol, it is likely that vastly greater numbers of individuals would have become infected.

The symptoms of inhalational anthrax are similar to those of many non-lethal diseases. In many cases of anthrax infection, by the time the correct diagnosis has been made the victim is dead or dying. If the infection is correctly diagnosed promptly, most anthrax infections can be treated with antibiotics such as penicillin, tetracycline, and the much more expensive ciprofloxacin (Cipro). During the recent anthrax attack, so many individuals who thought that they had been exposed demanded Cipro that the drug sold out at pharmacies, although more common antibiotics would have been just as effective.

Both the US and the Soviet Union (and probably some other countries) developed anthrax vaccines. The US vaccine uses Protective Antigen purified from cultures of *B. anthracis* lacking the capsule plasmid. The Soviet Union vaccine used live, attenuated, unencapsulated *B. anthracis*. Neither vaccine has undergone extensive testing; based on limited evidence, it is thought that the Soviet vaccine was more effective.

## Plague

*Yersinia pestis* bacteria cause the plague, the “Black Death” of medieval times. *Y. pestis* normally infects rodents (especially *Rattus rattus* black rats), using fleas as a vector. After infecting humans, *Y. pestis* infection initially causes bubonic plague, which must be transmitted by fleas. During epidemics, however, some cases of bubonic plague develop into pneumonic plague. Pneumonic plague is a highly contagious disease spread by aerosol.

Between 1346 and 1352, the Black Death killed about 25 million people in Europe, with an average mortality of 70 to 80%. After that period, outbreaks of plague of somewhat decreased severity continued in Europe until about 1720. The reason for the disappearance of the plague is not fully understood. One hypothesis for the decreased incidence suggests a reduced virulence of the *Y. pestis* bacteria (bacteria that are less lethal do not kill their host too quickly, and therefore have a chance to find additional hosts). Alternatively, because the plague killed many of the black rats, the brown rat (*Rattus norvegicus*, white forms of which are used as laboratory rats) became more common; brown rats associate less closely with humans, and are less likely to pass *Y. pestis* to humans. Finally, improved sanitation may have played a role in preventing epidemics, although most public health improvements did not occur until well after 1720.

Although European epidemics ended, the plague did not entirely disappear. An Asian epidemic began in 1894, killing about 14 million over the next 50 years.

The plague is relatively difficult to weaponize. One option is to produce an aerosol of the bacteria in an attempt to induce the pneumonic form of the plague. Another approach is to infect the human specific flea *Pulex irritans* with *Y. pestis*, and release the fleas in a populated area (this may have been done by the Japanese Unit 731 in China during World War II).

Individuals infected with plague can be treated with antibiotics. In undeveloped countries, endemic plague is contained by isolation of patients and by the use of insecticides (to kill the fleas) followed by measures intended to kill rodents (in this order, because killing the rodents first forces the fleas to find alternate hosts). A vaccine based on killed *Y. pestis* has been used occasionally; however, the vaccine does not protect against the pneumonic form of the plague.

## Smallpox

Smallpox is a highly contagious disease caused by **variola virus** that has historically been associated with a 30% mortality rate. Smallpox was declared eradicated by the World Health Organization in 1980 (smallpox is the only disease thought to be completely eradicated). Because smallpox virus only infects humans,

it has essentially been rendered extinct. The virus is known to exist at the CDC, the Centers for Disease Control and Prevention (Atlanta), and at VECTOR, the State Research Center of Virology and Biotechnology (Koltsovo, Russia). However, it is not known whether other countries have retained stocks of the virus, or have obtained stocks of the virus from the Soviet Union. In addition, the sequence of several strains of the virus has been determined; it is in principle possible to recreate the virus from a related virus such as monkeypox.

No known treatment exists for smallpox, although supportive treatment would probably prevent the secondary infections that historically killed many of the victims of smallpox. The **vaccinia virus** vaccine protects against the disease, and seems to protect exposed individuals even when administered a few days after exposure.

While many older individuals were vaccinated, routine vaccination ended at least twenty years ago in most countries. In the US, routine vaccination ended in 1972 because the vaccine is associated with a significant complication risk, especially in immunocompromised individuals. Because the vaccine does not offer life-long immunity, many of the vaccinated individuals are also at risk of developing the disease if exposed.

### Toxin weapons

In addition to pathogenic organisms, many biological compounds are highly toxic. These compounds will only affect individuals who are directly exposed to the toxin. The organic toxins are all non-volatile. To be active, the compounds must either be directly injected (as in the use of ricin to kill Georgi Markov) or must be converted into an aerosol.

When administered by injection or inhalation, biological toxins are the most lethal compounds known. A measure of lethality is the LD<sub>50</sub>, the dose required to kill 50% of the individuals exposed. The table below compares lethality of biological toxins to the nerve agents VX and sarin, which are some of the most toxic chemical compounds known.

Toxin	Estimated LD <sub>50</sub> (µg/kg of body weight)	Exposure method	Action
Botulinum toxin	0.001	Injection	Inhibition of acetylcholine release
Botulinum toxin	0.003	Inhalation	
Tetanus toxin	0.002		Interference with nerve transmission
Diphtheria toxin	0.1		ADP-ribosylation of eEF-2
Ricin	3.	Inhalation	23S rRNA inactivation
Ricin	20,000.	Ingestion	
VX	15.	Inhalation	Acetyl cholinesterase inhibition
Sarin	100.	Inhalation	Acetyl cholinesterase inhibition

Note the extreme toxicity of botulinum toxin, a protein produced by *Clostridium botulinum* bacteria that inhibits the release of acetylcholine from nerve terminals. In spite of the possibly lethal nature of this compound, it is sold as a drug under the

trade name “Botox”. The original use of Botox was for the treatment of diseases involving muscle spasms. More recently, it has been used as a cosmetic therapy; by causing muscles in the face to relax, Botox erases wrinkles, at the cost of limiting the facial expressiveness of the treated individual.

Making a weapon capable of causing mass casualties from one of these requires mass production of the toxin, followed by either release of the toxin in aerosol form or release of the toxin into the food or water supply. For most of these toxins, production of an aerosol is a formidable challenge, although it is likely that the Soviet Union produced some toxin-based weapons.

For most of these biological toxins, treatment is limited. Immunization may decrease the effectiveness of the toxin; for example, tetanus toxoid, a denatured form of the tetanus toxin, is fairly useful for preventing damage from the toxin. The most effective treatment is prevention; gas masks greatly diminish exposure. Unlike nerve agents such as VX, the biological toxins are not absorbed through the skin. Alternatively, the biological toxins are proteins, which can readily be rendered ineffective by heat treatment or the use of denaturants.

### **“Improving” biological weapons**

Biological weapons rely on pre-existing pathogenic organisms or toxins. However, as noted above the biological effect of these weapons may be limited if the intended victim is prepared. For example, anthrax and plague are caused by bacteria, and most individuals treated with antibiotics recover rapidly. Many biological weapons programs are thought to have attempted to avoid this possibility by incorporating antibiotic resistance into the weaponized bacteria; the simplest method for accomplishing this is to add a plasmid containing one or more antibiotic genes to the cells.

More sophisticated manipulations are based on genetic engineering techniques. One possibility is the creation of more virulent pathogens containing toxin genes from other pathogens. Another possibility is the development of a more contagious or more virulent disease (for example, a variant of the influenza virus) by mixing genes from different strains of the virus, or by adding genes from other viruses or other organisms. Creating a more pathogenic virus was thought to be fairly difficult; however, recently a modified mousepox virus was generated by the addition of a cytokine gene. The modified virus was vastly more virulent, and was found to be capable of killing mice that had been vaccinated against mousepox. It seems therefore that the creation of more deadly biological weapons may be a relatively simple process.

Biological weapons fall into two main categories. Some biological weapons (the toxins and non-contagious pathogens such as anthrax) are similar in general concept to classical chemical weapons. Although these weapons are capable of causing casualties in unprotected populations, their probable impact is limited by distribution method. Other biological weapons are contagious, and are in principle capable of causing epidemics rivaling those that devastated Europe in the 14<sup>th</sup> century and that wiped out large segments of the native population in the Americas following the arrival of the Europeans.

Recent events have suggested the possibility of terrorist attacks. For a terrorist, biological weapons have advantages. Biological weapons production is inexpensive and is essentially indistinguishable from the work performed in any microbiology laboratory. In addition, most biological weapons are difficult to detect until after people are already becoming ill. Finally, a contagious pathogen spreads itself widely, especially given the prevalence of air travel in the 21<sup>st</sup> century. On the other hand, “rational” terrorists (if this description is actually appropriate) might decide to avoid biological weapons because of the likelihood that the effects would include individuals from populations supporting the terrorist organization. In fact, the effect of a contagious disease is likely to be greater in the supportive populations, due to the lower level of healthcare in the poorer countries that appear to act as bases for most terrorist organizations.

From the perspective of the US, the threat of biological weapons is somewhat disturbing. Biological weapons are inexpensive, and do not necessarily reveal their site of origin. The maintenance of an open society makes preventing an attack difficult. The most obvious response is therefore an attempt to find treatments for possible biological weapons. The US has considerable biomedical research resources; the US may be well-advised to increase its funding of research into infectious disease.