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BIOTERRORISM

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BIOTERRORISM

INTRODUCTION

Terrorist attacks involving biological agents have increasingly become a concern in Canada, as well as in other nations. The types of potential bioweapons include bacteria and viruses as well as biologically derived toxins and poisons. In 1999, an expert panel convened by the U.S. Centers for Disease Control and Prevention (CDC) concluded that the greatest threat to public health was posed by the following six microorganisms:(1)

- **Smallpox** (*Variola major*)
- **Anthrax** (*Bacillus anthracis*)
- **Plague** (*Yersinia pestis*)
- **Botulism** (toxin secreted by *Clostridium botulinum*)
- **Tularemia** (*Francisella tularensis*)
- **Hemorrhagic fevers** (filovirus/arenavirus)

According to the CDC, these high-priority agents pose a risk to national security because they:

- can be easily disseminated or transmitted person-to-person;
- cause high mortality, with potential for a major impact on public health;
- might cause public panic and social disruption; and
- require special action for public health preparedness.(2)

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(1) Health Canada, "Bioterrorism and Public Health," *Canada Communicable Disease Report*, Vol. 27-04, February 2001, www.hc-sc.gc.ca/hpb/lcdc/publicat/ccdr/01vol27/dr2704ea.html.

(2) Centers for Disease Control and Prevention, "Agents/Diseases," Public Health Emergency Preparedness & Response, www.bt.cdc.gov/Agent/Agentlist.asp.

The CDC has also identified other microorganisms as potential agents that could be used for biological warfare. However, these have been placed in categories of lower importance. Among these are the bacteria that cause cholera, brucellosis, glanders or Q fever. A number of enteric bacteria, such as *Escherichia coli* and *Salmonella enteritidis*, can also be viewed as potential biological warfare agents.

Biological warfare has a surprisingly long history that is presumed to have started in prehistoric times. The **timeline** (see section near the end of this paper) has been punctuated by key scientific achievements and discoveries such as the identification of germs as agents of disease and the development of antibiotics.

The recent and sudden interest in bioterrorism has prompted the emergence of a wealth of information on all aspects of the issue. The quality of the information available is, however, highly variable. Inaccuracy or simply a lack of information combined with the fear generated by any terrorist attack has helped propagate a number of **myths** that should be dispelled. In these uncertain times, the general population often looks to all elected officials for guidance and reassurance.

Although the availability of microorganisms usable for biological warfare varies, in general these germs are relatively easy to breed but difficult to disseminate. Their lethality depends on the method of delivery used, weather conditions, and where victims encounter the germs. Potential targets of bioterrorism include public buildings or downtown areas, water supplies and, as recent events have shown, mail delivery systems. Scenarios of attacks vary in their degree of sophistication, from missiles to crop dusters, to powder hidden in packages. The degree of risk associated with these targets or scenarios differs according to their intrinsic characteristics.(3)

The issue of access to the microorganisms that cause these diseases is very important. In Canada, the Human Pathogens Importation Regulations are the regulatory authority for the importation and transfer of human pathogens. Extensive licensing and certification are outlined in Laboratory Biosafety Guidelines published by Health Canada's Office of Laboratory Safety.(4) All human pathogens that could potentially be used for biological warfare are also listed in the Chemical and Biological Weapons Non-proliferation List of the Department of Foreign Affairs and International Trade.(5)

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(3) Marilyn Werber Serafini, "Ignorance is no defense," *The National Journal*, 6 October 2001, pp. 3094-3096.

(4) www.hc-sc.gc.ca/pphb-dgspsp/ols-bsl/index.html.

(5) www.dfait-maeci.gc.ca/~eicb/export/contente.htm.

MYTHS AND REALITIES

A. Sources of the Current Anxiety

According to Jonathan Tucker,[6] the level of public anxiety about anthrax appears to be disproportionate to the current threat. To date, the various anthrax incidents in the United States have produced ten cases (four fatal) of inhalation anthrax (the most deadly form of the disease) and seven cases of skin anthrax, which is quite treatable if recognized within a reasonable amount of time. No cases have occurred in Canada, and the probability of such an attack is considered to be low. All the other incidents have involved either exposure to anthrax spores in doses too low to cause infection, or hoaxes involving harmless powders. Although inhalation anthrax is extremely serious, the victim must inhale at least 8,000 spores of the bacterium for infection to occur. Direct contact with powdered anthrax spores in an envelope is unlikely to cause inhalation anthrax but rather a much less serious skin infection. Finally, it is important to remember that anthrax is not contagious from person to person, and that all the incidents to date have involved low-tech methods of dissemination, affecting limited areas and small numbers of people. The ability to cultivate small amounts of anthrax spores and send them through the mail does not necessarily translate into the ability to stage a mass-casualty attack with anthrax, which would be technically far more difficult. However, these small-scale low-tech attacks can still have a very disruptive effect on our societies.

Another potential biological warfare agent is the smallpox virus. Smallpox is often considered the "worst-case" bioterrorist threat agent because it is infectious through the air, kills about a third of its victims, and is contagious from person to person. However, terrorists would have a hard time obtaining the virus because smallpox was eradicated from the human population by means of a global vaccination campaign. Samples of the smallpox virus currently exist only in a few laboratories (see additional comments below).

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(6) Jonathan B. Tucker interviewed by Kathryn Jean Lopez, National Review Online, 15 October 2001, www.nationalreview.com/interrogatory/interrogatoryprint101501.html. Tucker is director of the Chemical & Biological Weapons Nonproliferation Program at the Monterey Institute of International Studies in the Washington, D.C. office. He is also the author of *Scourge: The Once and Future Threat of Smallpox*, New York: Atlantic Monthly Press, 2001.

B. Ease of Production and Delivery of Biological Weapons

Although some biological warfare agents such as those that produce anthrax and botulism are common soil bacteria, they are not necessarily easy to convert into weapons. Other agents are virtually impossible to obtain from natural sources. For example, the smallpox virus was eradicated in 1977; the only remaining cultures are being kept under tight security in laboratories in Atlanta, Georgia in the United States and Koltsovo in Russia. Despite this, experts in biological weapons still consider smallpox a threat because in addition to these two secure repositories, circumstantial evidence suggests that undeclared stocks of smallpox virus may exist in countries of concern such as Iraq and North Korea. It is believed that some kind of state sponsorship would be required to obtain and develop these weapons.

Some experts affirm that anyone with a basic understanding of microbiology and several thousand dollars' worth of equipment can start a bio-weapons lab.(7) However, developing biological weapons is not as easy as it is portrayed in the media.(8) The resources of a government and scientific expertise are needed for a viable biological weapons program. Not only would a group have to isolate and culture an agent, but they would have to contain and deliver the agent. Containing an agent is the most troublesome part of using biological weapons, and one of the most important reasons they haven't been widely used. Bacteria and viruses don't discriminate between an ally and a foe, and the so-called boomerang effect – where the biological agent affects those who released it – represents a strong risk. Delivering a biological agent is difficult as well. Spreading a disease through the air would most likely involve delivering it in an aerosol cloud. Any change in the weather would make the behaviour of that cloud completely unpredictable. For some agents, the simplest method of dissemination would be for suicide terrorists to infect themselves with the virus and spread it in crowds, but even terrorists willing to die instantly in a "blaze of glory" might think twice about suffering the torments and disfigurement of smallpox.(9) Other delivery methods would also be technically challenging.

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(7) Dr. Leonard Cole, author of *The Eleventh Plague*, made this assertion to CBC Radio's *Quirks and Quarks* in 1998, in Amina Ali and John Bowman, "Biological Warfare," CBC News Online, 26 September 2001, www.cbc.ca/news/indepth/background/bioterrorism.html.

(8) Michael Moodie, president of the Chemical and Biological Arms Control Institute, speaking with *CBC Morning* in September 2001, in Ali and Bowman, *ibid.*, www.cbc.ca/news/indepth/background/bioterrorism.html.

(9) *Ibid.*

C. Government Response and Public Reaction

The Canadian government is taking steps to reduce the country's vulnerability to biological agents. The government has recently established both a Centre for Emergency Preparedness and Response, and the Canadian Science Centre for Human and Animal Health. The components of the Canadian response to bioterrorism are outlined in a Health Canada document available on its website.(10) The Minister of Health has also announced a number of initiatives in 2001 that reinforce these components.(11) The initiatives include:

- protocols for suspicious packages;
- command and control structure for critical decisions, allocation of resources, notifications and information provided to the public;
- training for front-line emergency response staff, physicians, medical personnel, and disease specialists to better recognize, diagnose, and treat illnesses;
- surveillance for detection of initial infection;
- laboratory detection by a country-wide network of diagnostic facilities;
- prophylaxis considerations including vaccination programs and provision of antibiotics;
- prevention of secondary infection (isolation and quarantine); and
- stockpiling by the National Emergency Services Stockpile (NESS) of Health Canada of drugs (not vaccines) and "field hospitals."

At this time, the drug stockpile has enough of various antibiotics to treat 40,000 people. There are plans to increase this number to 100,000. In addition, $5.6 million will be spent on stockpiling antibiotics to respond to anthrax. One of these antibiotics, ciprofloxacin, is still covered by a patent expiring in 2003. This antibiotic has not received approval for anthrax treatment in Canada although it has in the United States. At this time, the government has negotiated contracts with both the manufacturer holding the patent and a generic drug manufacturer for the production of ciprofloxacin. The government may override the patent held

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(10) Health Canada, "Bioterrorism and Public Health," *Canada Communicable Disease Report*, Vol. 27-04, February 2001, www.hc-sc.gc.ca/pphb-dgspsp/publicat/ccdr-rmtc/01vol27/dr2704ea.html.

(11) Health Canada, "New Health Security to Protect Canadians," Press Release, 18 October 2001, www.hc-sc.gc.ca/english/archives/releases/2001/2001_110e.htm.

by the manufacturer with the approval of the Patent Commissioner under the *Patent Law*, paragraph 19.1(2).

Critics, however, have recognized gaps in the degree of preparedness of our governments. Some of these deficiencies have or are being addressed at this time. According to Jonathan Tucker,(12) it is essential to:

- train doctors and nurse-practitioners so that they can recognize unusual diseases such as anthrax, plague and smallpox, which they would not normally encounter in their medical practice;
- improve staffing and communications at city, county and state health departments so that physicians can report suspicious cases by phone or e-mail on a 24/7 basis (24 hours a day, 7 days a week);
- increase the number of clinical laboratories around the country capable of diagnosing bioterrorist threat agents; and
- help hospitals to develop emergency-response plans for dealing with a range of attack scenarios.

Finally, individuals should also refrain from stockpiling antibiotics or taking them prophylactically for three reasons: the risk of side effects; overuse of antibiotics fosters the emergence of drug-resistant bacterial strains; and hoarding of antibiotics could deplete the national supply in the event of a real attack. Moreover, actions such as purchasing a gas mask are probably not a good investment because a bioterrorist attack would probably occur covertly and without warning. The agent cloud would be invisible and odourless, and thus individuals would not know when to don their masks to protect them from exposure. As a result, unless the mask was worn at all times, it would probably provide little protection.(13)

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(12) Jonathan B. Tucker (2001), www.nationalreview.com/interrogatory/interrogatoryprint101501.html.

(13) *Ibid.*

DISEASES

A. Summary Table

DISEASE	Smallpox[14]	Anthrax	Plague	Botulism	Tularemia fever[15]	Hemorrhagic fever
Causative organism	*Variola major*	*Bacillus anthracis*	*Yersinia pestis*	*Clostridium botulinum*	*Francisella tularensis*	*Numerous viruses*
Type of micro-organism	Virus	Bacteria	Bacteria	Bacterial toxin	Bacteria	Virus
Mode of delivery	Aerosol, contact	Aerosol, contact	Aerosol	Aerosol, food, water	Aerosol, water	Contact
Contagion	Yes	No	Yes	N/A	No	Yes
Prevention	Live attenuated vaccine, not recommended world-wide since 1980. New vaccine being developed	Vaccine, not recommended nor available for general public	Discontinued vaccine	Immunization with botulinum deactivated toxin, not recommended nor available for general public	Live attenuated vaccine	Control of vector population
Treatment	Supportive therapy only	Antibiotics (i.e. penicillin, doxycycline, tetracyclines, ciprofloxacin)	Antibiotics (i.e. streptomycin, tetracyclines, chloramphenicol)	Botulinum antitoxin, mechanical ventilation if required[16]	Antibiotic (streptomycin)	Supportive therapy only
Source	Two labs in U.S. and Russia, biowarfare programs	Diseased animals, veterinary laboratories, biowarfare programs, scientific supply houses	Arthropods, scientific supply houses	Soils, scientific supply houses, biowarfare programs	Soils, infected animal carcasses, biowarfare programs	Animal reservoirs, arthropod hosts

(14) Eradicated world-wide in 1977; antibiotic treatment for secondary infection.

(15) Highly infectious – takes as few as 10 organisms to trigger illness.

(16) Antibiotic treatment for secondary infection.

B. Smallpox

Smallpox infection is caused by the variola virus which was eradicated from the world in 1977.(17) Historically, smallpox has been universally feared as the most devastating of all infectious diseases. It is considered one of the most serious bioterrorist threats to civilian populations because of its high case-fatality rates and high transmissibility.(18)

Currently, there are only two known stores of variola virus in the world: one at the Centers for Disease Control and Prevention in Atlanta, Georgia, and one at the State Research Centre of Virology and Biotechnology (VECTOR) in Koltsovo, Russia.(19) Several attempts have been made to destroy the remaining official stocks of the virus; however, each time the deadline has been extended to allow for further study. A scientific panel established by the World Health Organization (WHO) in 1999 has until 2002 to set a final date.(20)

The incubation period for smallpox is approximately 12 days. Initial symptoms of smallpox may include high fever and fatigue as well as head and backache. Severe abdominal pain and delirium are sometimes present. In 2-3 days a characteristic rash will develop, first on the mucosa of the mouth and pharynx, but most prominently on the face, arms and legs.(21) Scabs develop, separate, and fall off after 3-4 weeks leaving pigment-free skin behind. Pitted scars eventually form. Most smallpox patients recover, but death occurs in up to 30% of cases.(22)

Smallpox is transmitted from person to person by infected saliva droplets. Infected persons are most infectious during the first week of illness, when the largest amount of virus is present in their saliva. Nonetheless, risk of transmission remains until all scabs have fallen off. Contaminated clothing or bed linen can also spread the virus; these must be steam-sterilized as a precaution against transmission.(23)

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(17) F. Fenner, D.A. Henderson, I. Arita, Z. Ježek and I.D. Ladnyi, *Smallpox and its Eradication*, Geneva: World Health Organization, 1988, p. vii.

(18) Johns Hopkins University Center for Civilian Biodefense Studies, "Smallpox Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentsmallpox.html.

(19) World Health Organization (WHO), "Future Research on Smallpox Virus Recommended," Press Release 77, 10 December 1999, www.who.int/inf-pr-1999/en/pr99-77.html.

(20) "Stay of Execution," *New Scientist*, May 1999, www.newscientist.com/hottopics/bioterrorism/bioterrorism.jsp?id=21880600.

(21) Centers for Disease Control and Prevention, "Facts about Smallpox," www.bt.cdc.gov/DocumentsApp/FactSheet/SmallPox/About.asp.

(22) Johns Hopkins University Center for Civilian Biodefense Studies, "Smallpox Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentsmallpox.html.

(23) *Ibid.*

There are no proven antiviral agents effective in treating smallpox. If administered within four days of exposure, smallpox vaccine may lessen the severity of or even prevent illness.(24) Treatment of smallpox is primarily limited to supportive therapy and antibiotics as required for secondary bacterial infections.(25)

In 1796, Edward Jenner demonstrated that infection with cowpox imparted protection from smallpox.(26) The WHO began a world-wide campaign in 1967 to eradicate the disease. By 1977, the last case was diagnosed; and in 1980 the World Health Assembly recommended ending vaccination throughout the world. In that same year, the Canadian manufacturer, Connaught Laboratories, now Aventis Pasteur, discontinued production of the smallpox vaccine.(27) Although a handful of physicians continued to vaccinate patients after 1980, few Canadians under the age of 21 are vaccinated,(28) and the immunity of individuals vaccinated prior to 1980 may not be sufficient to prevent infection.(29) At this time, the country has enough smallpox vaccine to immunize 380,000 people. This leftover stock from the vaccination campaign terminated in the mid-1970s is old, but has been determined effective. In addition, current research indicates that the vaccine could potentially be diluted and remain effective. Such a dilution would permit the immunization of as many as 3-4 million Canadians.(30) The American biopharmaceutical company Acambis has been awarded a $343 million contract to develop and produce a new smallpox vaccine by the U.S. government, specifically for combatting the threat of bioterrorism.(31)

Allegations made in the late 1990s by a Soviet defector charge that the former Soviet Union's bioweapons programs are capable of producing several tons of smallpox virus

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(24) Centers for Disease Control and Prevention, "Facts about Smallpox," www.bt.cdc.gov/DocumentsApp/FactSheet/SmallPox/About.asp.

(25) D.A. Henderson *et al.*, "Smallpox as a Biological Weapon: Medical and Public Health Management," *Journal of the American Medical Association*, Vol. 281, No. 22, June 1999, p. 2132.

(26) *Ibid.*

(27) Telephone conversation with company representative, 18 October 2001.

(28) P. Varughese, Health Canada, Division of Immunization, Bureau of Infectious Diseases, 16 October 2001 (personal communication).

(29) Centers for Disease Control and Prevention, "Facts about Smallpox," www.bt.cdc.gov/DocumentsApp/FactSheet/SmallPox/About.asp.

(30) Allan Rock, Minister of Health, witness to the Standing Committee of Health, 25 October 2001.

(31) Acambis Product Information, www.acambis.com/cfm/index.cfm?cvar=1_displayprod&prodid=58481885.

each year and that more virulent and infectious strains are being investigated.(32) The variola virus is very stable in aerosol form and the infectious dose appears to be quite small; it would therefore disseminate swiftly if released as an aerosol.(33)

C. Anthrax

Anthrax is an acute infectious disease caused by spore-forming bacteria called *Bacillus anthracis*. The spore stage of the bacterial life cycle has developed as a mechanism by which these organisms may endure periods of unfavourable conditions and then resume normal growth once conditions have improved. In its spore form, anthrax is extremely hardy, capable of surviving in soils for decades in adverse environments.(34) Anthrax most commonly occurs in hoofed mammals (cattle, goats, sheep, camels and antelopes), but it can also infect humans if they are exposed to infected animals or tissue from infected animals, or if they are directly exposed to the spores after the intentional release of anthrax as a bioweapon.(35) Anthrax has been developed as part of biological weapons programs in several countries, including the United States and the Soviet Union. The number of nations currently working on anthrax weapons programs is unknown.(36)

Symptoms of anthrax usually emerge within seven days of initial exposure but may take up to 6-8 weeks to develop. Symptoms will also vary depending on the method of transmission.(37) Direct person-to-person spread is extremely unlikely, if it occurs at all.(38) Anthrax may be transmitted to humans in three ways:(39)

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(32) Henderson *et al.* (1999), p. 2128.

(33) Johns Hopkins University Center for Civilian Biodefense Studies, "Smallpox Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentsmallpox.html.

(34) Health Canada, "Bacillus anthracis," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds12e.html.

(35) Johns Hopkins University Center for Civilian Biodefense Studies, "Anthrax Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentanthrax.html.

(36) T.V. Inglesby *et al.*, "Anthrax as a Biological Weapon: Medical and Public Health Management," *Journal of the American Medical Association*, Vol. 281, No. 18, May 1999, p. 1735.

(37) Johns Hopkins University Center for Civilian Biodefense Studies, "Anthrax Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentanthrax.html.

(38) Centers for Disease Control and Prevention, "Facts about Anthrax," www.bt.cdc.gov/DocumentsApp/FactSheet/Anthrax/about.asp.

(39) The following descriptions were adapted from Johns Hopkins University Center for Civilian Biodefense Studies, "Anthrax Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentanthrax.html; and Health Canada, "Bacillus anthracis," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds12e.html.

- *Intestinal*: Consuming infected meat products may result in the intestinal form of anthrax. This is characterized by acute infection of the intestinal tract. Initial signs of nausea, loss of appetite, vomiting and fever are followed by abdominal pain, vomiting of blood and severe diarrhea. In 25-60% of cases, intestinal anthrax results in death.
- *Cutaneous*: 95% of infections occur when *Bacillus anthracis* enters a cut or abrasion on the skin, for example, by handling infected wool, hides, leather or hair products of infected animals. Cutaneous infection begins as a raised itchy bump that resembles an insect bite. Within 1-2 days this will develop into a vesicle, then a painless ulcer 1-3 cm in diameter; at the centre, an area of black necrotic (dying) tissue will form. When treated with antibiotics, deaths are rare; left untreated, death occurs in roughly 20% of cases.
- *Inhalation*: Initial symptoms will resemble those of a common cold. After several days, symptoms may progress to severe breathing problems and shock. Inhalation anthrax is commonly fatal.

Antibiotics may be prescribed to treat anthrax; in order to be effective, these should be administered early. Because of the risk that infection may reoccur due to dormant spores, it is recommended that patients be kept on their antibiotic regimen for 60 days, especially in cases of inhalation anthrax.(40) Anthrax is susceptible to penicillin, doxycycline, tetracyclines and ciprofloxacin.(41) The Minister of Health, Allan Rock, has announced that the Canadian government has a large enough stockpile of antibiotics to treat 40,000 individuals, and that its aim is to increase this number to 100,000.(42)

In the United States, a protein-based human anthrax vaccine was licensed for use in 1970 and the licence for its production was granted to the State of Michigan by the Food and Drug Administration. The public company responsible for the vaccine's production, Michigan Biologic Products Institute, was subsequently privatized and then sold to BioPort Corporation.(43) In December of 1997, the U.S. Secretary of Defense announced that all military personnel were

(40) Inglesby *et al.* (1999), "Anthrax," pp. 1740-1741.

(41) Health Canada, "Bacillus anthracis," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds12e.html.

(42) Chris Cobb, "Manley urges calm as anthrax scares multiply: 'Not a single case in Canada,'" *The Calgary Herald*, 17 October 2001.

(43) Office of the Inspector General, "Contracting for Anthrax Vaccine – Report No. D-2000-105," Department of Defense, 22 March 2000, www.dodig.osd.mil/audit/reports/fy00/00105sum.htm.

to be inoculated with the anthrax vaccine; and in 1998, BioPort Corporation was granted an exclusive $45.1 million contract with the U.S. Department of Defense to manufacture, bottle, and store the anthrax vaccine; funds were also allocated for equipment and renovations.(44) However, no vaccine is currently available for civilian use nor is civilian vaccination recommended.(45) In addition, BioPort has failed to pass FDA inspections specifically regarding the anthrax vaccine; without approval by the FDA, BioPort cannot sell or distribute the drug.(46) In Canada, the anthrax vaccine is not licensed for use, but it can be obtained through official channels from the CDC.(47)

Were anthrax to be deployed as a bioweapon, it would most likely be in the aerosol form, as this would disseminate more readily and result in the highest mortality. An aerosol cloud of anthrax spores would be difficult to detect, and the first indication of such an attack would be a spike in patients with inhalation anthrax symptoms.(48) However, converting anthrax to the appropriate aerosol form requires sophisticated biotechnology equipment and knowledge.(49)

D. Plague

Plague is caused by the bacteria *Yersinia pestis*, which is found in rodents and their fleas, in many areas around the world.(50) Historically, plague pandemics have ravaged numerous parts of the globe killing millions. Natural outbreaks such as these are unlikely to occur today, thanks to advances in public health, living conditions and antibiotic therapy.(51) In

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(44) *Ibid.*

(45) Centers for Disease Control and Prevention, "Facts about Anthrax," www.bt.cdc.gov/DocumentsApp/FactSheet/Anthrax/about.asp.

(46) Office of the Inspector General, "Contracting for Anthrax Vaccine – Report No. D-2000-105," Department of Defense, 22 March 2000, www.dodig.osd.mil/audit/reports/fy00/00105sum.htm.

(47) Health Canada, "Bacillus anthracis," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds12e.html.

(48) Johns Hopkins University Center for Civilian Biodefense Studies, "Anthrax Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentanthrax.html.

(49) Inglesby *et al.* (1999), "Anthrax," p. 1736.

(50) Health Canada, "Yersinia pestis," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds169e.html.

(51) Johns Hopkins University Center for Civilian Biodefense Studies, "Plague Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentplague.html.

the 1950s and 1960s, U.S. and Soviet biological weapons programs developed techniques to aerosolize plague particles. To avoid the unpredictability associated with animal vectors, a bioterrorist attack with plague would most likely use an aerosolized form of the bacteria.(52) Aerosol release of *Yersinia pestis* would also primarily result in pneumonic plague, the more deadly form of the disease, as opposed to the bubonic or septicemic forms, which are normally contracted from flea populations.(53)

Pneumonic plague occurs when *Yersinia pestis* infects the lungs. Initial symptoms begin to appear after 1-6 days; these include fever, headache, weakness and coughing that produces bloody or watery sputum. As the pneumonia progresses it may induce septic shock and, in the absence of early treatment, death.(54)

Pneumonic plague can be spread from one person to another via respiratory droplets, but this requires face-to-face contact with an infected person.(55) Left untreated, pneumonic plague kills almost all its victims.(56) Pneumonic plague can be treated with several antibiotics such as streptomycin, tetracyclines and chloramphenicol. A vaccine against *Yersinia pestis* has been shown to provide some level of protection against the bubonic form of the disease but not against the pneumonic form. The production of this vaccine was discontinued in 1999.(57)

In 1995, an Ohio lab technician was able to place an order for three vials of *Yersinia pestis* using only a credit card and a false letterhead. It was subsequently discovered that he had links to a white supremacist organization and the man eventually pled guilty to mail fraud. New antiterrorism legislation in the United States requires the CDC to more closely monitor the circulation of infectious agents.(58)

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(52) T.V. Inglesby *et al.*, "Plague as a Biological Weapon: Medical and Public Health Management," *Journal of the American Medical Association*, Vol. 283, No. 17, May 2000, p. 2282.

(53) Johns Hopkins University Center for Civilian Biodefense Studies, "Plague Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentplague.html.

(54) Inglesby *et al.* (2000), "Plague," p. 2282.

(55) Centers for Disease Control and Prevention, "Facts about Pneumonic Plague," www.bt.cdc.gov/DocumentsApp/FactSheet/Plague/About.asp.

(56) Johns Hopkins University Center for Civilian Biodefense Studies, "Plague Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentplague.html.

(57) Inglesby *et al.* (2000), "Plague," p. 2285.

(58) Leonard A. Cole, "The Specter of Biological Weapons," *Scientific American*, www.sciam.com/1296issue/1296cole.html.

E. Botulism

Botulism is a muscle-paralyzing disease caused by a toxin produced by the bacterium *Clostridium botulinum*. The most poisonous substance known, botulinum toxin poses a major bioweapons threat because of its extreme potency and lethality, its ease of production and transport, and the potential need for prolonged medical care.(59) The toxin works by inhibiting communication between neurons (by binding to synapses and blocking the release of the neurotransmitter acetylcholine), thereby causing muscle paralysis.(60)

Between 1990 and 1995, the Japanese cult Aum Shinrikyō made several futile attempts to release aerosolized botulinum toxin at a number of sites in Tokyo and at U.S. military installations in Japan. The toxin was acquired from *Clostridium botulinum* collected from soils in northern Japan.(61) Several nations have also explored the use of botulinum toxin as a bioweapon, including the United States, the former Soviet Union, Japan and Iraq.(62)

Botulism may occur if a person's wounds become infected with *Clostridium botulinum*. In a small number of cases, infants who harbour the bacterium in their intestinal tract may succumb to the disease. Foodborne botulism occurs when botulinum toxin is ingested directly.(63) Symptoms from foodborne botulism usually emerge within 12 to 36 hours and include double vision, blurred vision, drooping eyelids, difficulty speaking and/or swallowing and muscle weakness that always descends through the body. Paralysis of breathing muscles may occur, leading to death if mechanical ventilation is not provided.(64)

There have been rare cases of natural botulism, usually stemming from inadequate heating of contaminated food. The toxin is odourless, colourless and tasteless but it is inactivated at temperatures above 85ºC.(65) Botulism cannot be spread from one person to

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(59) Stephen S. Arnon *et al.*, "Botulinum Toxin as a Biological Weapon: Medical and Public Health Management," *Journal of the American Medical Association*, Vol. 285, No. 8, May 2001, p. 1059.

(60) Johns Hopkins University Center for Civilian Biodefense Studies, "Botulinum Toxin Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentbotox.html.

(61) Arnon *et al.* (2001), p. 1060.

(62) *Ibid.*, p. 1060.

(63) Centers for Disease Control and Prevention, "Facts about Botulism," www.bt.cdc.gov/DocumentsApp/FactSheet/Botulism/about.asp.

(64) *Ibid.*

(65) Johns Hopkins University Center for Civilian Biodefense Studies, "Botulinum Toxin Fact Sheet," www.hopkins-biodefense.org/pages/agents/agentbotox.html.

another. Although botulinum toxin can survive in water, it is killed by chlorine, so standard water treatment techniques would ensure safety of drinking water unless the toxin could be introduced after treatment.(66)

An antitoxin against botulism exists and can reduce the severity of symptoms if taken early enough. Recovery from botulism usually takes several weeks to months of supportive care.(67)

F. Tularemia

Tularemia is caused by the bacteria *Francisella tularensis*, the most infectious bacterium known, and requires inoculation or inhalation of as few as 10 organisms to trigger illness.(68) It is considered a serious potential bioweapon because of its ease of dissemination and significant ability to cause illness and death.(69) Many nations have studied and/or stockpiled tularemia over the past century, including Japan, the United States and the Soviet Union. Such studies have primarily focused on the dissemination of *Francisella tularensis* as an aerosol.(70)

Francisella tularensis is a non-sporing organism that can survive for many weeks at low temperatures in moist soil, water, straw or animal carcasses.(71) The natural reservoirs of this bacterium include small mammals (such as voles, mice, squirrels and rabbits), wild birds, some domestic animals, and various insects (such as ticks, deerflies and mosquitoes). Human-to-human transmission does not occur.(72)

Francisella tularensis can infect humans through their skin, mucous membranes, gastrointestinal tract and their lungs. The general symptoms of tularemia include fever, fatigue, chills and headache.(73) Infection via airborne tularemia initially results in acute febrile illness,

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(66) *USA Today*, "Bioterrorism pathogens: a primer," www.usatoday.com/graphics/news/gra/gbioterror/frame.htm.

(67) Arnon *et al.* (2001), pp. 1066-1067.

(68) David T. Dennis *et al.*, "Tularemia as a Biological Weapon: Medical and Public Health Management," *Journal of the American Medical Association*, Vol. 285, No. 21, June 2001, p. 2763.

(69) *Ibid.*, p. 2763.

(70) *Ibid.*, p. 2764.

(71) Health Canada, "*Francisella tularensis*," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds68e.html.

(72) *Ibid.*

(73) Dennis *et al*. (2001), pp. 2766-2767.

which can progress to secondary pulmonary infection within 3-5 days. Aerosol contact may also cause eye infection, oral ulcers or conjunctivitis. Upon infection, the primary organs targeted are the lungs, lymph nodes, spleen, liver and kidneys.(74) Left untreated, patients may succumb to respiratory failure, shock and finally death.(75)

Tularemia may be treated with the antibiotic streptomycin.(76) There is a live attenuated vaccine for tularemia routinely used to protect individuals who work with the bacterium.(77)

G. Hemorrhagic Fevers

Hemorrhagic fevers are a group of illnesses caused by several families of viruses. Some of these diseases are mild, but many can be life-threatening.(78) The natural reservoir for these viruses are animal hosts (such as rodents) and arthropod vectors (such as ticks and mosquitoes). However, for some of these viruses (e.g., the Ebola virus), the natural host remains unknown.(79) Despite the fact that humans are not the natural reservoirs for these viruses, human-to-human transmission can still occur, either directly or indirectly via contact with contaminated body fluids.(80) Examples of viral hemorrhagic fevers include:

- Dengue hemorrhagic fever
- Ebola hemorrhagic fever
- Hantavirus pulmonary syndrome
- Crimean-Congo hemorrhagic fever
- Bolivian hemorrhagic fever
- Yellow fever
- Marburg hemorrhagic fever
- Lassa fever
- Argentine hemorrhagic fever
- Venezuelan hemorrhagic fever

(74) *Ibid.*

(75) Johns Hopkins University Center for Civilian Biodefense Studies, "Tularemia Fact Sheet," www.hopkins-biodefense.org/pages/agents/agenttularemia.html.

(76) Health Canada, "*Francisella tularensis*," Material Safety Data Sheet – Infectious Substances, Population and Public Health Branch, www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/msds68e.html.

(77) *Ibid.*

(78) Centers for Disease Control and Prevention, Special Pathogens Branch, "Disease Information, Viral Hemorrhagic Fevers: Fact Sheets," www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/vhf.htm.

(79) *Ibid.*

(80) *Ibid.*

Studies of weaponized forms of hemorrhagic fevers have been pursued in both the former Soviet Union as well as the United States.(81) In 1992, members of the Japanese Aum Shinrikyō cult traveled to Zaire under the pretext of providing aid to Ebola victims. However, a 1995 report by the U.S. Senate's Permanent Subcommittee on Investigations charged that their true aim was to collect samples of the virus for use in future biological attacks.(82) It is important to note that all but two of the hemorrhagic fevers are caused by viruses requiring biosafety level four (the highest level) of equipment and facilities in order to work with them safely.(83)

Although the symptoms of viral hemorrhagic fevers vary from one to the other, some general symptoms can be identified; these include fever, fatigue, dizziness, muscle aches and exhaustion. In severe cases, victims may exhibit the following symptoms: shock, nervous system malfunction, coma, delirium, seizures, as well as bleeding from body orifices, under the skin or in internal organs.(84)

Viral hemorrhagic fevers have no established treatments or cures. Additionally, there are no vaccines for these diseases. The only method of prevention is to avoid contact with the host species, making rodent and insect population control extremely important in combatting viral hemorrhagic fevers.(85)

HISTORY OF BIOLOGICAL AND CHEMICAL WARFARE(86)

Biological and chemical warfare are generally associated with the technological advances that created modern warfare in the 20th century. But the use of poison and disease in war, against soldiers and citizens alike, dates back much further, even before the discovery of

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(81) Marilyn Werber Serafini, "Ignorance is no defense," *National Journal*, 6 October 2001, pp. 3094-3096.

(82) Leonard A. Cole, "The Specter of Biological Weapons," *Scientific American*, www.sciam.com/1296issue/1296cole.html.

(83) Centers for Disease Control and Prevention, Special Pathogens Branch, "Disease Information, Viral Hemorrhagic Fevers: Fact Sheets," www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/vhf.htm.

(84) *Ibid.*

(85) *Ibid.*

(86) Sources: CBC news and ABC news websites, www.cbc.ca/news/indepth/background/bioterrorism.html and www.abcnews.go.com/sections/nightline/DailyNews/timeline_biowar.html.

bacteria in the 17th century and germs in the 19th century. Almost as soon as humans figured out how to make arrows, they were dipping them in animal feces to poison them.

The Roman Empire used animal carcasses to contaminate their enemies' wells. This had the effect of both demoralizing their enemies and making them sick. Knowing that a demoralized, sick army is an easier one to beat resulted in this strategy being used again in Europe's many wars, in the American Civil War and even into the 20th century.

184 BC: Carthaginian leader Hannibal is credited with an interesting use of biological weapons. In anticipation of a naval battle with the Pergamenes, he ordered his troops to fill clay pots with snakes. During the battle, Hannibal sent the pots crashing down on the deck on the Pergamene ship. The confused Pergamenes lost the battle, having to fight both Hannibal's forces and a ship full of snakes.

1346: During the siege of Kaffa, a Genoese port on the Crimean peninsula in the Black Sea, the attacking Tartars are devastated by an outbreak of the plague. They are forced to abandon the siege, but before leaving they use catapults to hurl the plague-infested bodies of their dead comrades over the walls of the city. The plague spreads through the city, whose fleeing residents then take it to Italy. The second outbreak of "black death" in Europe can be partly blamed on biological warfare.

1518: In Latin America, Spanish conquistador Hernando Cortes exposes the Aztec to smallpox, which soon devastates the native population, paving the way for Cortes' complete victory in 1521. In the 1530s, a similar smallpox epidemic spreads throughout the Incan civilization as a result of the arrival of the Spanish.

1710: During the war between Russia and Sweden, Russian troops are said to use the cadavers of plague victims to provoke an epidemic among the enemy.

1767: During the French and Indian War in North America, an English general, Sir Jeffery Amherst, gives blankets infected with smallpox to Indians who are helping the French defend Fort Carillon. The English have twice attacked Fort Carillon and both times were repulsed with heavy losses. But the smallpox ploy works, causing an epidemic that decimates the Indians and allows Amherst to capture the fort and rename it Fort Ticonderoga.

1914-1918: World War I sees the first large-scale use of chemical weapons such as chlorine and mustard gases. In 1915, Germany uses gas warfare at the village of Langemarck near Ypres in France. Britain and France soon start

to use gas too. By 1918, one in every four artillery shells fired contains gas of one type or another.

1925: Chemical warfare in World War I leads to the Geneva Protocol, which prohibits the use of biological or chemical weapons in warfare, but does not ban the research or production of these agents. Every great power of the world ratifies the protocol except the United States and Japan.

1930s and 1940s: Japan experiments with biological agents and uses biological weapons in China and Manchuria.

1942: On Gruinard Island, off the coast of Scotland, the British conduct anthrax tests on sheep. Today, the uninhabited island is still believed to be infected with anthrax spores.

1969: Richard Nixon announces a new U.S. policy on biowarfare: "The U.S. shall renounce the use of lethal biological agents and weapons, and all other methods of biological research." Nixon pledges the nation will never use biological weapons under any circumstances. The entire U.S. arsenal is destroyed by 1973, except for seed stocks held for research purposes.

1972: The Biological Weapons Convention is established. The treaty prohibits the research, development and production of offensive biological weapons. The treaty does allow defensive work in the area of biological weapons. The Soviet Union and the United States both ratify the pact. Canada is among the 103 countries that signed the convention.

1979: An unusual anthrax outbreak in the Soviet city of Sverdlovsk kills at least 64 people. The Soviet government blames the outbreak on contaminated meat, but there is suspicion within the international scientific and intelligence communities that the Sverdlovsk outbreak was caused by an accidental release of anthrax spores from a nearby suspected biological weapons facility. All evidence available to the U.S. government indicates a massive release of aerosolized *B. anthracis* spores. In 1992, Russian President Boris Yeltsin acknowledges that the incident was indeed related to the microbiology facility.

1980-88: Chemical weapons are used extensively during the Iran-Iraq war, mainly by Iraq. After the Gulf War, in 1991, the United Nations Security Council orders Iraq to halt its biological, chemical and nuclear weapons programs. The U.N. Special Commission (UNSCOM) begins post-war inspections that have continued with numerous interruptions and obstacles thrown up by Iraq.

1995: Members of the Aum Shinrikyō religious sect release sarin gas in the Tokyo subway system, killing 12 commuters and injuring more than 5,000. Due to the poor quality of the sarin agent and an ineffective dispersal system, casualties are lower than expected. Afterward, the religious group

is found to have been experimenting with anthrax and other biological agents.

1998: The U.S. Defense Department begins an anthrax vaccination program to immunize all military personnel against anthrax.

2001: The Biological Weapons Convention still allows for research into defences, such as vaccines, against biological weapons. Early in September 2001, the Pentagon announced it was developing a deadly new form of anthrax, for defensive research.

A. Timeline of Scientific Achievements Related to Biological Warfare

1675: After learning to grind lenses, Dutch scientist and tradesman Anthony Leeuwenhoek makes simple microscopes, and becomes the first human to see bacteria.

1796: First scientific smallpox vaccination produced by Edward Jenner.

1855: Louis Pasteur, the father of microbiology, begins working with yeast, eventually proving it is made up of living organisms. His work uncovers the existence of germs and their disease capabilities.

1867: Joseph Lister practices antiseptic surgery.

1876: First proof of Germ Theory of Disease with *B. anthracis* discovery by Robert Koch.

1881-82: Robert Koch grows bacteria on solid media and outlines "Koch's postulates."

1885: Louis Pasteur develops the first rabies vaccine.

1892: Dmitri Iosifovich Ivanovski discovers viruses.

1900: Walter Reed proves that mosquitoes carry the yellow fever agent.

1928: Sir Alexander Fleming, a Scottish bacteriologist, discovers penicillin, the first antibiotic.

1953: James Watson and Francis Crick describe the double helix nature of DNA.

1977: Walter Gilbert and Frederick Sanger develop a method to sequence DNA.

1983: Kary Mullis develops the Polymerase Chain Reaction technique.

1995: The first microbial genomic sequence (*H. influenzae*) is published.

SUGGESTED INTERNET LINKS

- The *Journal of the American Medical Association* is offering five free articles that cover the use of tularemia, botulinum toxin, plague, anthrax and smallpox as biological weapons (www.ama-assn.org/ama/pub/category/6232.html).

- The U.S. Military's Anthrax Vaccine Immunization Program (www.ama-assn.org/ama/pub/category/6232.html).

- BioPort Corporation is the U.S. producer of the anthrax vaccine (www.bioport.com).

- The statement from the Minister of Health on the anthrax cases in the United States is posted on this site which includes links to an anthrax fact sheet (www.hc-sc.gc.ca/english/anthrax.htm).

- The Centers for Disease Control and Prevention have posted a page with links to several documents relating to anthrax, including a fact sheet (www.bt.cdc.gov/Agent/Anthrax/Anthrax.asp).

- The Johns Hopkins University Center for Civilian Biodefense Studies has fact sheets on several biological agents (www.hopkins-biodefense.org/pages/agents/agent.html); the Center also has a section of papers dealing with various subjects related to bioterrorism (www.hopkins-biodefense.org/pages/library/published.html).

- The *Canadian Medical Association Journal* has a paper on the history of smallpox in Canada (www.cma.ca/cmaj/vol-161/issue-12/1543.htm), as well as a paper on anthrax (www.cma.ca/cmaj/vol-163/issue-5/0608.htm).

- The Canadian Security Intelligence Service (CSIS) has issued a report entitled "Chemical, Biological, Radiological and Nuclear (CBRN) Terrorism" (www.csis-scrs.gc.ca/eng/miscdocs/200002_e.html).

- The Material Safety Data Sheets are available from the Office of Laboratory Security division of the Health Canada website (note: agents are not listed under their common names, i.e., anthrax is listed under the bacteria that causes it, *Bacillus anthracis*) (www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/index.html).

- The Canadian Food Inspection Agency also has information on anthrax (inspection.gc.ca/english/anima/heasan/disemala/anthraxe.shtml), as well as information on foodborne botulism (inspection.gc.ca/english/corpaffr/foodfacts/botulisme.shtml).