WEAPONS OF MASS DESTRUCTION

BIOLOGICAL WEAPONS

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The use of biological agents as bioweapons has its roots in ancient times, when the concepts of bacteria, toxin or virus were not known yet. Over 2,000 years ago, rudimentary techniques of biological warfare resolved the first disputes among people.

Hand by hand with the evolution of modern science (especially in the 18th century), the possibility of using biological agents as bioweapons has been refined.

In the last few decades, the development of innovative biotechnology techniques has provided the knowledge to create more aggressive bioweapons. These new organisms cause great concern, because they can produce devastating and completely unexpected effects, of the same level or even higher than the most dangerous wild type biological agents.

Although international conventions prohibit the use of biological agents for offensive purposes, it is known that many terrorist groups continue their research about the possible use of biological agents as bioweapons.

The concerns related to biological agents are aroused, as well as the effects in terms of victims, both from the objective difficulties in the detection of a potential attack. A release of biological agents is difficult to detect with current technology, especially when it comes to a stand-off revelation compared to point detection.

Biological agents have a unique feature when compared to other non-conventional weapons (chemical or radiological); with the exception of toxins, they are able to multiply in the host and in turn be transmitted to other individuals.

Hence, immediate identification of a biological attack is essential, in order to take appropriate containment measures to contain further dissemination. Therefore, there is a clear need to develop new technologies to detect biological agents from long-range, in order to take immediate action in the event of both intentional and unintentional biological agents releases.

- Orlando Cenciarelli, Defence S&T Tech. Bull., 6(2): 111-129, 2013

Biological warfare: The early days

- An early example takes us back more than 2 and a half millennia: Assyrians infected their enemy's wells with a rye **ergot fungus**, which contains chemicals related to LSD. Consuming the tainted water produced a confused mental state, hallucinations, and, in some cases, death.
- In the 1300s, Tartar (Mongol) warriors besieged the Crimean city of Kaffa. During the siege, many Tartars died at the hands **of plague**, and their lifeless, infected bodies were hurled over the city walls.
- Some researchers believe that this tactic may have been responsible for the spread of Black Death plague into Europe. If so, this early use of biological warfare caused the eventual deaths of around 25 million Europeans.
- **This is a prime example of biological warfare's potential scope, unpredictability, and terrifying simplicity.**

Biological warfare: The early days

- Moving forward to 1763, the British Army attmped **to use smallpox** as a weapon against Native Americans at the Siege of Fort Pitt. In an attempt to spread the disease to the locals, the Brits presented blankets from a smallpox hospital as gifts.

Although we now know that this would be a relatively ineffective way to transmit smallpox, the intent was there.

- During World War II, many of the parties involved looked into biological warfare with great interest. The Allies built facilities capable of mass producing **anthrax spores**, **brucellosis**, and **botulism toxins.**

Thankfully, the war ended before they were used.

- It was the Japanese who made the most use of biological weapons during World War II, as among other terrifyingly indiscriminate attacks, the Japanese Army Air Force dropped ceramic bombs full of fleas carrying **the bubonic plague** on Ningbo, China.

Biological warfare: The early days

- “The Japanese army poisoned more than 1,000 water wells in Chinese villages to study **cholera** and **typhus outbreaks**. Some of the epidemics they caused persisted for years and continued to kill more than 30,000 people in 1947, long after the Japanese had surrendered.”
- *Dr. Friedrich Frischknecht, professor of integrative parasitology, Heidelberg University, Germany*

- Scientific research on biological weapons did not begin until the 19th century, after discoveries made by scientists such as Koch, Pasteur and Lister.

Biological warfare: The early days

In 1972, was on the water main in Chicago and in St. Louis water contaminated with **typhus.**

- In 1984, an attempt was made to use **botulinum toxin** in Paris.
- In 1986, 715 people in Oregon contracted **salmonellosis** from a deliberately contaminated lettuce.
- In 1995, a man was detained ordering a **plague bacterium** from the United States, and two people were convicted of planning a murder using **ricin**.
- Activities of the infamous Japanese sect Aum Shinrikyo (1995 **sarin attack** in the Tokyo subway, 1990-95 eight attempts to disperse **anthrax** and **botulinum toxin spores** in the streets of Tokyo, 1993 an attempt to obtain **the Ebola virus** under the guise of a humanitarian mission in Zaire).
- Distribution of powder with **anthrax** disputes in postal items (2001 USA).

1925 The Geneva Protocol prohibits the use of biological weapons in war.

• In 1969, the United States announced a unilateral and unconditional withdrawal from biological weapons.

In 1972, the US Department of Defense issued a statement ending the liquidation of all BZ stocks.

• 26. March 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Biological Weapons.

• Development of biological weapons in Libya, Syria, China, Iran, Iraq, the former Soviet Union (autobiographical statement by Dr. Ken Alibek alias Kanatjan Alibekov, director of the Soviet complex of biological weapons research, production and storage centers "Biopreparat",

• 1979 accident with **anthrax aerosol** leak in Sverdlovsk region (68 deaths out of 79 affected.)

Biological agent

A **biological agent** (also called **bio-agent**, **biological threat agent**, **biological warfare agent**, **biological weapon**, or **bioweapon**) is a bacterium, virus, protozoan, parasite, or fungus that can be used purposefully as a weapon in bioterrorism or biological warfare (BW).

In addition to these living or replicating pathogens, toxins and biotoxins are also included among the bio-agents.

More than 1,200 different kinds of potentially weaponizable bio-agents have been described and studied to date.

Infectious diseases lose many of their usual peace characteristics (IDs change, seasonality, endemicity and professionalism occur, the proportion of various clinical forms of the disease changes, etc.).

Bioterrorism

is the deliberate release of viruses, bacteria, toxins or other harmful agents to cause illness or death in people, animals, or plants.

These agents are typically found in nature, but could be mutated or altered to increase their ability to cause disease, make them resistant to current medicines, or to increase their ability to be spread into the environment.

Biological agents can be spread through the air, water, or in food. Biological agents are attractive to terrorists because they are extremely difficult to detect and do not cause illness for several hours to several days.

Some bioterrorism agents, like the smallpox virus, can be spread from person to person and some, like anthrax, cannot.

Bioterrorism

- Utilizing such weapons holds a certain appeal to terrorists; they have the potential to cause great harm, of course, but they are also fairly cheap to produce when compared with missiles or other more hi-tech equipment.
- DaSilva (1999) defined biological warfare as the intentional use of microorganisms, and toxins, generally of microbial, plant or animal origin, to produce diseases and deaths among humans, livestock and crops.
- Biological warfare and bioterrorism are very complex subjects, mainly due to the many agents that can be used as weapons and for the wide range of ways for dissemination into the environment and population.

- Most biological weapons (except, for example, toxins and bacterial spores) have a unique quality that other non-conventional weapons (such as chemical and radiological) do not have; biological agents are able to multiply in the host organism and be transmitted in turn to new hosts, generating in this way with unpredictable effects on the population, both in terms of number of victims and geographical spread (Rotz et al., 2002; Zalini, 2010; Vogel, 2012; Tucker, 2013).

- Among the reasons which make bioweapons attractive is their very low cost when compared to both conventional and unconventional weapons

Categories of Biological Agents The U.S. Centers for Disease Control and Prevention (CDC) defines a bioterrorism attack as “the deliberate release of viruses, bacteria or other germs (agents) used to cause illness or death in people, animals, or plants” (CDC, 2013).
It classifies biological agents into three categories

- 1. Category A: Agents that can be easily disseminated or transmitted from person to person. They result in high mortality rates and have the potential for major public health impact. They might cause public panic and social disruption, and require special action for public health preparedness.
- 2. Category B: Agents that are moderately easy to disseminate. They result in moderate morbidity rates and low mortality, and require specific enhanced diagnostic capacity and disease surveillance.
- 3. Category C: Emerging agents that could be engineered for mass dissemination in the future because of their availability. They are easy to produce and disseminate. They are potentially linked to high morbidity and mortality rates, and major health impact.

Table 1: Major biological agents that are possible to be used as bioweapons (CDC, 2013).

Groups	Diseases	Agents
A	Anthrax	*Bacillus anthracis*
	Botulism	*Clostridium botulinum* toxin
	Plague	*Yersinia pestis*
	Smallpox	*Variola major*
	Tularemia	*Francisella tularensis*
	Viral hemorrhagic fevers	*Filoviruses and Arenaviruses*
B	Brucellosis	*Brucella spp.*
	Epsilon toxin	*Clostridium perfringens*
	Food safety threats	*Salmonella* spp., *E.coli* O157:H7, *Shigella*
	Glanders	*Burkholderia mallei*
	Melioidosis	*Burkholderia pseudomallei*
	Psittacosis	*Chlamydia psittaci*
	Q fever	*Coxiella burnetii*
	Ricin toxin	*Ricinus communis*
	Staphylococcal enterotoxin B	*Staphylococcus spp.*
	Typhus fever	*Rickettsia prowazekii*
	Viral encephalitis	*Alphaviruses*
	Water safety threats	*Vibrio cholerae*, *Cryptosporidium parvum*
C	Emerging infectious diseases	*Nipahvirus* and *Hantavirus*

Generally, biological agents (included those used as bioweapons) can be further classified according to certain characteristics that define the hazard to health (NATO, 1996):

- a. Infectivity: The aptitude of an agent to penetrate and multiply in the host.
- b. Pathogenicity: The ability of the agent to cause a disease after penetrating into the body.
- c. Transmissibility: The ability of the agent to be transmitted from an infected individual to a healthy one
- d. Ability to neutralise: Its means to have preventive tools and / or therapeutic purposes.

Biological agents can be transmitted through one or more ways. The transmission modes are the following (La Placa, 2010):

- a. Parenteral: Agents that are transmitted through body fluids or blood.
- b. Airway (by droplets): Agents that are emitted by infected people, which can then be inhaled by surrounding people.
- c. Contact: Through which the agents present on the surface of the infected organism can infect another organism.
- d. Faecal-oral route: Through objects, foods or other items contaminated with the faeces of infected patients, or through sexual contact.

Table 2: Fatality rates of Category A biological agents.

Pathogen	Biological Agent	Fatality rate (%)	Reference
Bacteria	*Bacillus anthracis*	Cutaneous: <1% Respiratory: 75% Gastrointestinal: 25%-60%	CDC, 2013
	Clostridium botulinum	Foodborne: 3-5% Wound and intestinal: 15%	
	Yersinia pestis	8-10%	WHO, 2004
	Francisella tularensis	Subspecies *tularensis*: 2%	WHO, 2007; Dennis *et al.*, 2001
		Subspecies *holarctica*: fatal cases are rare	WHO, 2007
Virus	*Variola major*	30%	CDC, 2013
	Filoviridae	90%	Warfield *et al.*, 2005
	Arenaviridae	15-30%	Briease *et al.*, 2009

Table 3: Biosafety levels (BSL) required to work with Category A biological agents.

Pathogen	Biological Agent	BSL	Reference
Bacteria	*Bacillus anthracis*	3	WHO, 2004
	Clostridium botulinum	3	Arnon *et al.*, 2001
	Yersinia pestis	2-3	WHO, 2004
	Francisella tularensis	3	Bhalla & Warheit, 2004
Virus	*Variola major*	4	DHHS, 2009
	Filoviridae	4	
	Arenaviridae	2-3	

Potential Biological Weapons

Below is a list of a few biological organisms that may potentially be used as biological weapons.

Microbe	Natural Environment	Target Host	Mode of Contraction	Diseases/Symptoms
Anthrax Bacillus anthracis	Soil	Humans, Domestic Animals	Open Wounds, Inhalation	Pulmonary Anthrax Septicemia, Flu-like symptoms
Clostridium botulinum	Soil	Humans	Contaminated Food or Water,	Inhalation
Clostridium perfringens	Intestines of humans and other animals, Soil	Humans, Domestic Animals	Open Wounds	Gas gangrene, Severe Abdominal Cramps, Diarrhea
RICIN Protein Toxin	Extracted from Castor Bean Plants	Humans	Contaminated Food or Water, Inhalation, Injection	Severe Abdominal Pain, Watery and Bloody Diarrhea, Vomiting, Weakness, Fever, Cough, and Pulmonary Edema
Smallpox	Eradicated from Nature, Now Obtained from Laboratory Stockpiles	Humans	Direct Contact with Bodily Fluids or Contaminated Objects, Inhalation	Persistent Fever, Vomiting, Rash on Tongue and in Mouth, Rash and Bumps on Skin

Bacterial bio-agents (Military Symbol)

Tularemia	Francisella tularensis (SR or JT)
Plague	Yersinia pestis (LE)
Melioidosis	Burkholderia pseudomallei (HI)
Listeriosis	Listeria monocytogenes (TQ)
Glanders	Burkholderia mallei (LA)
Dysentery (bacterial)	Shigella dysenteriae, some species of Escherichia coli (Y)
Diphtheria	Corynebacterium diphtheriae (DK)
Cholera	Vibrio cholerae (HO)
Brucellosis (porcine)	Brucella suis (US, AB or NX)
Brucellosis (caprine)	Brucella melitensis (AM or BX)
Brucellosis (bovine)	Brucella abortus
Anthrax	Bacillus anthracis (N or TR)

Chlamydial bio-agents

Psittacosis	Chlamydophila psittaci (SI)

Rickettsial bio-agents

Q Fever	Coxiella burnetii (OU)
Rocky Mountain spotted fever	Rickettsia rickettsii (RI or UY)
Typhus (human)	Rickettsia prowazekii (YE)
Typhus (murine)	Rickettsia typhi (AV)

Viral bio-agents

Equine Encephalitis (Eastern)	Eastern equine encephalitis virus (ZX)
Equine Encephalitis (Venezuelan)	Venezuelan Equine Encephalomyelitis virus (FX)
Equine Encephalitis (Western)	Western equine encephalitis virus (EV)
Japanese B encephalitis	Japanese encephalitis virus (AN)
Rift Valley fever	Rift Valley fever virus (FA)
Smallpox	Variola virus (ZL)
Yellow fever	Yellow fever virus (OJ or LU)

Mycotic bio-agents

Coccidiomycosis	Coccidioides immitis (OC)

Biological toxins

Toxin	Source of Toxin (Military Symbol)
Abrin	Rosary pea (*Abrus precatorius*)
Botulinum toxins (A through G)	*Clostridium botulinum* bacteria or spores, and several other Clostridial species. (X or XR)
Ricin	Castor bean (*Ricinus communis*) (W or WA)
Saxitoxin	Various marine and brackish cyanobacteria, such as *Anabaena*, *Aphanizomenon*, *Lyngbya*, and *Cylindrospermopsis* (TZ)
Staphyloccocal enterotoxin B	Staphylococcus aureus (UC or PG)
Tetrodotoxin	Various marine bacteria, including *Vibrio alginolyticus*, *Pseudoalteromonas tetraodonis* (PP)
Trichothecene mycotoxins	Various species of fungi, including *Fusarium*, *Trichoderma*, and *Stachybotrys*

Biological vectors

Vector (Military Symbol)	Disease
Mosquito (Aedes aegypti) (AP)	Malaria, Dengue fever, Chikungunya, Yellow fever, other Arboviruses
Oriental rat flea (Xenopsylla cheopis)	Plague, Murine typhus

Origins of Current Concern about Bioterrorism

Douglas C. Lovelace, Jr., the Director of the Strategic Studies Institute, suggests four reasons bioterrorism has become a concern in the last generation:

- The first, beginning around 1990 ...was the official U.S. Government suggestion that proliferation of offensive BW programs...was an increasing trend.
- The second was the discovery ...that the USSR...had built a massive covert biological weapons program...
- The third was the corroboration by the United Nations Special Commission in 1995 that Iraq ... had stockpiled large quantities of agents
- ... The last was the discovery, also in 1995, that the Japanese Aum Shinrikyo group ...had spent 4 years attempting ...to produce ...two pathogenic biological agents. (December 2005)