International
BIOLOGICAL THREAT REDUCTION

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Biological WMD:
The Threat from States

Jennifer Gaudioso, Ph.D.
International Biological Threat Reduction
International Security Center
Sandia National Laboratories
Albuquerque, NM USA
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www.biosecurity.sandia.gov

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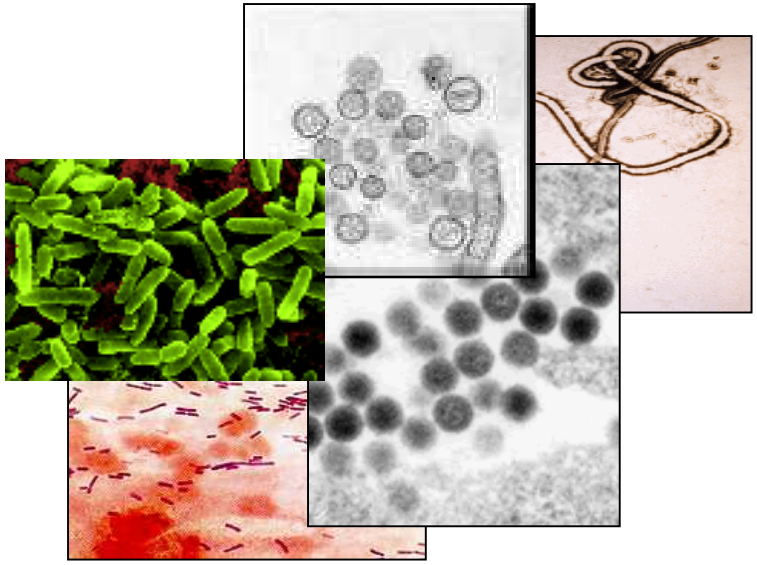
National Nuclear Security Administration

Sandia National Laboratories

Biological Weapons (BW)

- **According to the Biological Weapons Convention, biological weapons are:**
  - **"Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes."**



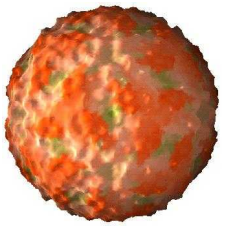
BW is Different Than Other WMD

- Naturally-occurring
  - With only a few notable exceptions:
    - Variola major virus
    - 1918 Influenza virus
- Dual-use
  - Materials
  - Technologies
  - Expertise
- Wide variety of materials
  - Deadly to incapacitating
  - Human, animal, zoonotic, plant
- Self-replicating
  - Minute quantities of concern
- Not detectable at a distance
- Present in many types of facilities
  - Research laboratories, clinical laboratories, hospitals
  - Private and public sector
- Present at multiple locations within a facility
  - In laboratory, in storage, in animals, in waste stream
- Synthetic biology
  - De-novo synthesis
  - Turning non-pathogenic material into virulent organism

Source: Jonathan B. Tucker, “Biosecurity: Limiting Terrorist Access to Deadly Pathogens,” Peaceworks No. 52, United States Institute of Peace, November 2003.

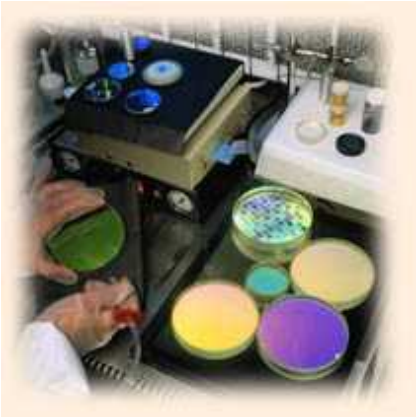
Technical Requirements for Biological Weapons Use

- Acquisition
- Development
- Dissemination



FMD virus

The advance of biotechnology has facilitated the development of BW capability



Acquisition for Biological Weapons

- Sources of *high risk agents*
  - Bioscience facilities
  - Culture collections
  - Natural environment
  - Genetic modification / chemical synthesis

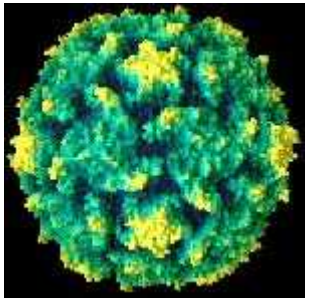
- Technical requirements
  - Identify and isolate material
  - Select strain

- Acquisition of BW is facilitated by the advance of biotechnology
  - Publications, patents, internet-based outbreak monitoring provide increasing information on the location of *high risk agents*
  - Over time, more individuals will obtain skills and technologies to create *high risk agents* through chemical synthesis and genetic engineering

Chemical Synthesis of Biological Weapons

- **Published experiments**
  - 2002 – polio virus
  - 2003 – phi-X174 virus
- **Materials**
  - DNA synthesizer
  - DNA sequencer
  - Nucleotides, plasmids, enzymes
- **Challenges**
  - Obtaining complete, accurate genome
  - Correct synthesis of large genomes
  - Avoiding minor errors resulting in loss of desirable attribute (e.g. virulence, hardiness, transmissibility…)
  - Outsourcing of DNA sequencing may attract attention
- **Challenges are diminishing with time**
  - More genomes being sequenced, improved accuracy
  - Improved techniques
  - Protocol refined through documented research, experienced scientists

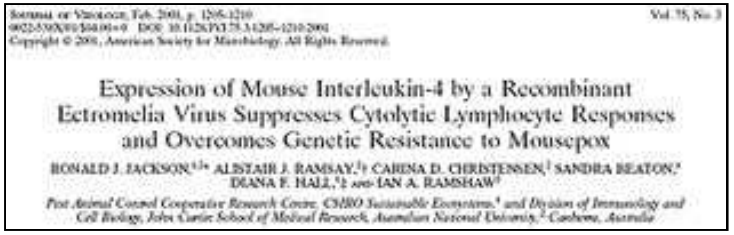
DNA Synthesizer



Polio Virus

Genetic Modification for Biological Weapons

- Published experiments
  - 2001 - IL-4 mousepox
- Materials
  - DNA splicer
  - Plasmids
- Challenges
  - Identification of correct strand to modify; knowledge of how to modify it
  - Need to avoid unintended effects that weaken desirable attributes
  - Difficult to predict which modifications will create desired effect
- Technical hurdles diminishing with time
  - Expertise in genetic engineering growing rapidly with the advance of biotechnology
  - Further availability of relevant technologies and equipment

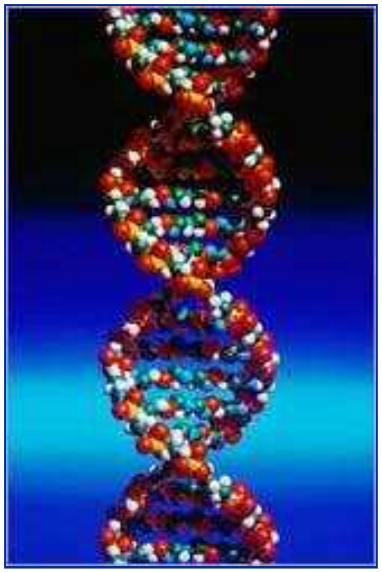


Journal of Virology, Feb. 2001, p. 1205–1210 Vol. 75, No. 3
0022-538X/01/$04.00+0 DOI: 10.1128/JVI.75.3.1205–1210.2001

Expression of Mouse Interleukin-4 by a Recombinant Ectromelia Virus Suppresses Cytolytic Lymphocyte Responses and Overcomes Genetic Resistance to Mousepox

RONALD J. JACKSON,[1,2]* ALISTAIR J. RAMSAY,[1]† CARINA D. CHRISTENSEN,[1] SANDRA BEATON,[2] DIANA F. HALL,[2]‡ AND IAN A. RAMSHAW[1]

Post Animal Cosmel Cooperative Research Centre, CSIRO Sustainable Ecosystems,[1] and Division of Immunology and Cell Biology, John Curtin School of Medical Research, Australian National University,[2] Canberra, Australia



Production of Biological Weapons

- Goal: adequate quantity in an adequate form

- Technical requirements
  - Appropriate growth media
  - Rapid PCR
  - Amplification
  - Processing
    - To withstand environmental stressors
    - To survive dissemination
    - To aerosolize for optimal dissemination

- Production of BW is facilitated by the advance of biotechnology
  - Instructions for isolating agents, making growth media, and growing cultures are available on the internet, and will proliferate
  - Increasingly more people, with less training, can master amplification skills; may also be true for effective processing skills

Dissemination of Biological Weapons

- Primary modes of infection
  - Inhalation
  - Percutaneous
  - Ingestion

- Technical requirements
  - Development of effective delivery mechanism
  - Assessment of meteorological conditions

- Dissemination of BW is facilitated by the advance of technology
  - Pharmaceutical companies process organisms to withstand environmental stressors and effective aerosol delivery systems
  - Efficient global travel enhances the opportunity for disease to spread

State-Based BW Programs

History of Biological Weapons

- 1346: Tartar invaders catapulted plague-infected bodies over city walls during siege of Kaffa

- 1763: British soldiers distributed blankets used by smallpox victims to Native Americans during French and Indian Wars
- World War I
  - Germany, France - anti-livestock sabotage

- World War II – 1972
  - Japan, USSR, US, UK, Canada
    - Japanese use against Chinese targets
    - Alleged USSR use against German soldiers
- Intent and effect of BW use was tactical, not strategic (influence battle, not war)

Summary of State Programs before the BWC Entered into Force (1975)

State	Year	Types of Activities
Germany	1914-1945 (sporadic)	R&D and deployment
France	1914-1941 (sporadic)	R&D and possible deployment
Japan	~1918-1945	R&D, production, and deployment
Soviet Union	1920s-1975	R&D, production, and possible deployment
United Kingdom	1936-1969	R&D and production
Canada	Post WWI-1969	R&D and production
United States	1942-1969	R&D and production

Source: Reynolds M. Salerno, Jennifer Gaudioso, Rebecca L. Frerichs, and Daniel Estes "A BW Risk Assessment Based on Historical and Technical Perspectives," Nonproliferation Review, Fall-Winter 2004.

Biological Weapons Convention (BWC)

- Prohibits the development, production, and stockpiling of biological weapons agents, toxins, equipment, and means of delivery by State Parties
- Opened for signature April 1972; entered into force March 1975
  - 171 State Parties (16 signatories have not ratified; 23 non-signatory nations)
- No provisions for verification of compliance
  - Dual-use nature of biological materials, technologies, and expertise present significant challenges
  - Extreme difficulty of discerning between legitimate and illegitimate biological research

Fermentation Vessels

Failure of the BWC

- **Biopreparat: The civilian arm of the Soviet biological weapons program**
  - **Established *after* Soviet accession into the BWC**
  - **40 – 50 facilities with up to 60,000 employees**
- **Other incidents**
  - **Iraq research program prior to 1991 Gulf War**
  - **Assassination of Bulgarian dissident**
  - **Alleged South Africa program to assassinate anti-apartheid activists**
- **Other suspected BW programs since 1972**
  - **Iran, North Korea, Syria, Sudan, Cuba**

Production Facility in Kazakhstan

Munitions in Iraq

Summary of State Programs after the BWC Entered into Force

State	Year	Types of Activities
Soviet Union/Former Soviet Union	1975-present	R&D, production, and possible deployment
Iraq	1980s-(2003)?	R&D and production
Iran	? (intensified in 1995)-present	R&D
China	1950s–present	R&D
Syria	?-present	R&D
Libya	?-present	R&D
India	?-present	R&D
Pakistan	?-present	R&D
North Korea	1960s-present	R&D and possible production
South Africa	?-1994	R&D, production, and possible deployment
Sudan	?-present (?)	R&D
Israel	?-present	R&D
Taiwan	?-present	R&D
Egypt	?-present	R&D

Source: Reynolds M. Salerno, Jennifer Gaudioso, Rebecca L. Frerichs, and Daniel Estes "A BW Risk Assessment Based on Historical and Technical Perspectives," Nonproliferation Review, Fall-Winter 2004.

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Scenarios for State Biological Weapons Proliferation

Objectives	Acquisition	Development	Dissemination
• Defensive use in asymmetric scenario • Offensive use in regional conflicts between symmetric states • Battlefield or other territory denial • Troop incapacitation	• Legitimate lab or culture collection (theft or fraud) • Provided by another State • Derived from natural sources • Genetic engineering or chemical synthesis • Theft from transport	• Advanced laboratory capabilities - Weaponize - Grow - Test - QA - Store - Transport	Sophisticated dissemination methods: • Ordinance (battlefield) • Missile • Airplane / UAV • Large-scale sprayer

BWC and Verification

- Unlike most other weapons treaties, BWC lacks a verification regime to monitor compliance
- 1991 – VEREX was established to explore possible verification measures from a technical perspective
- 1994 – Ad Hoc Group created to develop binding verification protocol
- 2001 – Protocol rejected amidst much controversy

- Dual-use Dilemma
  - Materials, equipment, expertise
  - How do you verify intent?

Efforts to Strengthen the BWC

- At 5th Review Conference (2002), State Parties agree to hold annual meetings:
  - 2003
    - Penal legislation
    - Strengthening security of biological agents
  - 2004
    - Strengthening ability to respond, investigate, and mitigate disease outbreaks from natural or deliberate causes
  - 2005
    - Developing codes of conduct
- At 6th Review Conference (2006), State Parties established a secretariat and agreed to continue holding annual meetings in 2007 – 2010
  - Enhancing national implementation
  - Measures to improve laboratory biosecurity
  - Scientific codes of conduct
  - Peaceful scientific cooperation including disease surveillance
  - Assistance to any country that is a victim of a BW attack

Contact Information

Jennifer Gaudioso, Ph.D.
Sandia National Laboratories
PO Box 5800, MS 1371
Albuquerque, NM 87185
USA
Tel. 505-284-9489
email: jmgaudi@sandia.gov

www.biosecurity.sandia.gov