44.348: ADVANCED SEMINAR ON WEAPONS OF MASS DESTRUCTION AND TERRORISM

Week 3: Biological Weapons

Dr. James Forest

ATTRIBUTES

Biological weapons intentionally disseminate agents of infectious diseases to harm or kill others.

Humans can be a means for delivery/dissemination as well as the victims

Key attributes of biological agents include:

- Infectivity - the ability of a pathogen to establish an infection
- Virulence/Pathogenicity - the ability of that infection to produce a disease
- Toxicity - the damage to humans or agriculture that can be caused by that disease
- The incubation period between infection and symptoms of the disease
- Transmissibility – how easily it can be transmitted from person to person
- The lethality or killing power of that disease
- And the stability of the pathogen

PREFERRED CHARACTERISTICS FOR WEAPONS

About 30 pathogenic microbes are considered good biological weapons, based on several key characteristics:

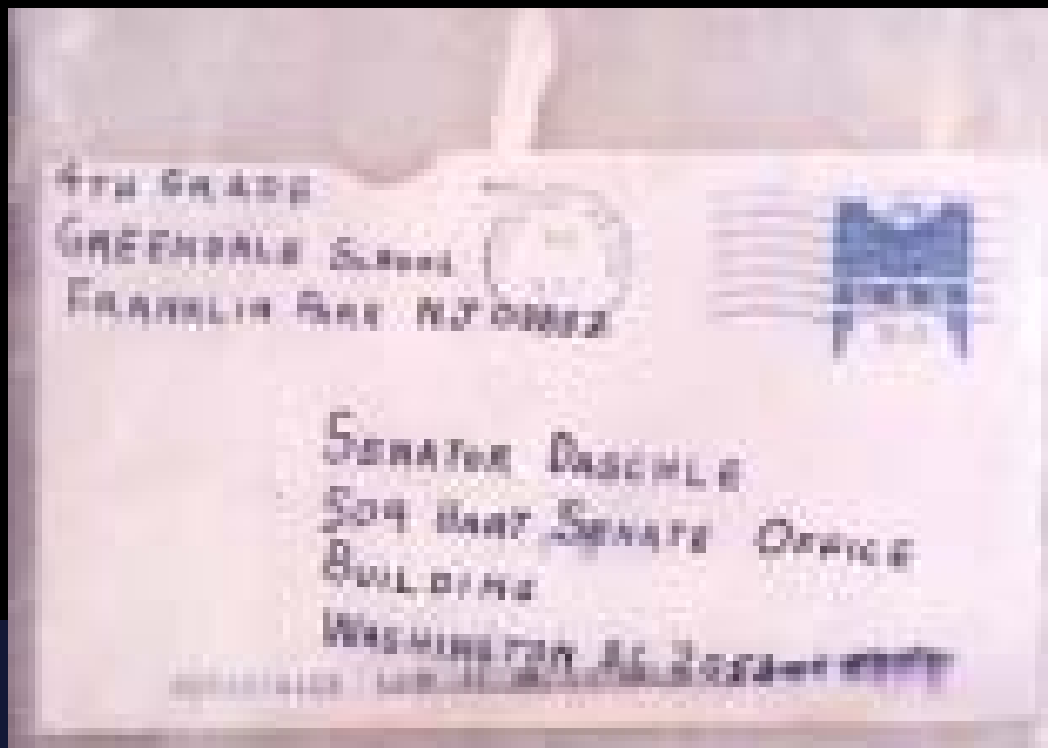
- Ability to reliably infect people in small doses
- High virulence (capacity to cause illness, incapacitation or death)
- Short incubation period between infection and onset of symptoms
- Minimal contagiousness
- No widespread immunity
- Not treatable with common antibiotics
- Suitable for production in military quantities
- Ease of storage, transport, and dissemination under wartime conditions
- Resilience
- Availability of protection for our own troops

PRODUCTION AND DELIVERY

Biological agents are hundreds to thousands of times more potent than chemical agents by weight.

<u>Biological agents can be distributed through</u>

- Heating, ventilation, and air conditioning (HVAC) systems
- Pressurized sprayers mounted on trucks, airplanes, UAVs
- Food/water contamination
- Envelopes/packages
- Infected blankets or clothing
- Explosive munitions



Anthrax letter sent to Senator Tom Daschle's Office in 2001

COMMON TYPES

* Bacteria (like Anthrax, Brucellosis, Tularemia, Plague)

* Viruses (Smallpox, Marburg, Yellow Fever)

* Rickettsia (Typhus fever, Spotted fever)

* Fungi (the molds that cause stem rust of wheat and rye)

* Toxins (like Ricin, Botulinum and Saxitoxin)
  a.k.a. "midspectrum"

* Infectious Pathogens:
  Emerging threats; SARS, Avian Influenza
  'Old' threats: TB, HIV, Malaria

CATEGORY A

High-priority agents include organisms or toxins that pose the highest risk to the public and national security because:

- They can be easily spread or transmitted from person to person
- They result in high death rates and have the potential for major public health impact
- They might cause public panic and social disruption
- They require special action for public health preparedness

Agents/Diseases

- Anthrax (*Bacillus anthracis*)
- Botulism (*Clostridium botulinum* toxin)
- Plague (*Yersinia pestis*)
- Smallpox (variola major)
- Tularemia (*Francisella tularensis*)
- Viral hemorrhagic fevers (filoviruses [e.g., Ebola, Marburg] and arenaviruses [e.g., Lassa, Machupo])

Source: Centers for Disease Control, http://www.bt.cdc.gov/agent/agentlist-category.asp

EXAMPLE: ANTHRAX

- Anthrax is a disease caused by bacterium
- Not known to spread from one human to another
- Three types:
  - skin (cutaneous): about 20% of cases are fatal *if untreated*
  - digestive (gastrointestinal): about 25%-50% of cases are fatal
  - lungs (inhalation): about 50% of cases are fatal
- Symptoms can appear within 7 days of contact with anthrax bacterium
- Treatable with vaccine, various antibiotics

Anthrax as a weapon:

- Dangerous, easily available with low cost of production
- Does not need advanced technology
- Knowledge about anthrax (source, culturing, transportation and dispersion) is widely available
- Easy to produce in large quantities and relatively easy to weaponize
- Extremely stable and can be stored indefinitely as a dry powder and the bacteria can multiply even in its dormant stage
- Not contagious

EXAMPLE: SMALLPOX

- More dangerous than Anthrax, very contagious
- Caused by the **variola** virus

- Symptoms include high fever, head and body aches, vomiting, and a prominent rash, starts on the tongue, spreads to face, arms, legs, hands, and feet

- Four major types: ordinary (90% of cases), modified (mild, affects previously vaccinated people), flat and hemorrhagic (both rare)
  - Ordinary smallpox is roughly 30% fatal
  - Flat and hemorrhagic are usually 100% fatal

- Humans are the only natural hosts of the variola virus
- Not as contagious as the measles, the flu or whooping cough.
- Prevention through vaccine, but no specific treatment of infection

CATEGORY B

The **second highest priority** agents:

- are moderately easy to spread
- result in moderate illness rates and low death rates
- require specific enhancements of CDC's laboratory capacity and enhanced disease monitoring

Agents/Diseases

- Brucellosis (*Brucella* species)
- Epsilon toxin of *Clostridium perfringens*
- Food safety threats (e.g., *Salmonella* species, *Escherichia coli* O157:H7, *Shigella*)
- Glanders (*Burkholderia mallei*)
- Melioidosis (*Burkholderia pseudomallei*)
- Psittacosis (*Chlamydia psittaci*)
- Q fever (*Coxiella burnetii*)
- Ricin toxin from *Ricinus communis* (castor beans)
- Staphylococcal enterotoxin B
- Typhus fever (*Rickettsia prowazekii*)
- Viral encephalitis (alphaviruses [e.g., Venezuelan equine encephalitis, eastern equine encephalitis, western equine encephalitis])
- Water safety threats (e.g., *Vibrio cholerae*, *Cryptosporidium parvum*)

Source: Centers for Disease Control, http://www.bt.cdc.gov/agent/agentlist-category.asp

EXAMPLE: RICIN

- Ricin is a poison found naturally in castor beans
- When weaponized, it can be in the form of a powder, a mist, or a pellet, or it can be dissolved in water or weak acid.
- Symptoms and effects include:
  1) **Inhalation**: difficulty breathing, fever, cough, nausea, and tightness in the chest, all within 8 hours of exposure; potentially fatal within 72 hours
  2) **Ingestion or injection**: vomiting and diarrhea, severe dehydration, and low blood pressure, all within less than 6 hours of exposure; possible liver, spleen and kidney failure; potentially fatal within 48 hours
  3) **Skin and eye exposure** has limited effects; unlikely to be fully absorbed through normal skin contact, but can cause redness, pain
- **No antidote exists for ricin**
- If exposed, remove clothing, wash entire body, get fresh air, and get medical care immediately

CATEGORY C

The <u>third highest priority agents</u> include emerging pathogens that could be engineered into weapons to cause mass casualties.

- They are easily available
- They are easily produced and spread
- They have potential for high morbidity and mortality rates and major health impact.

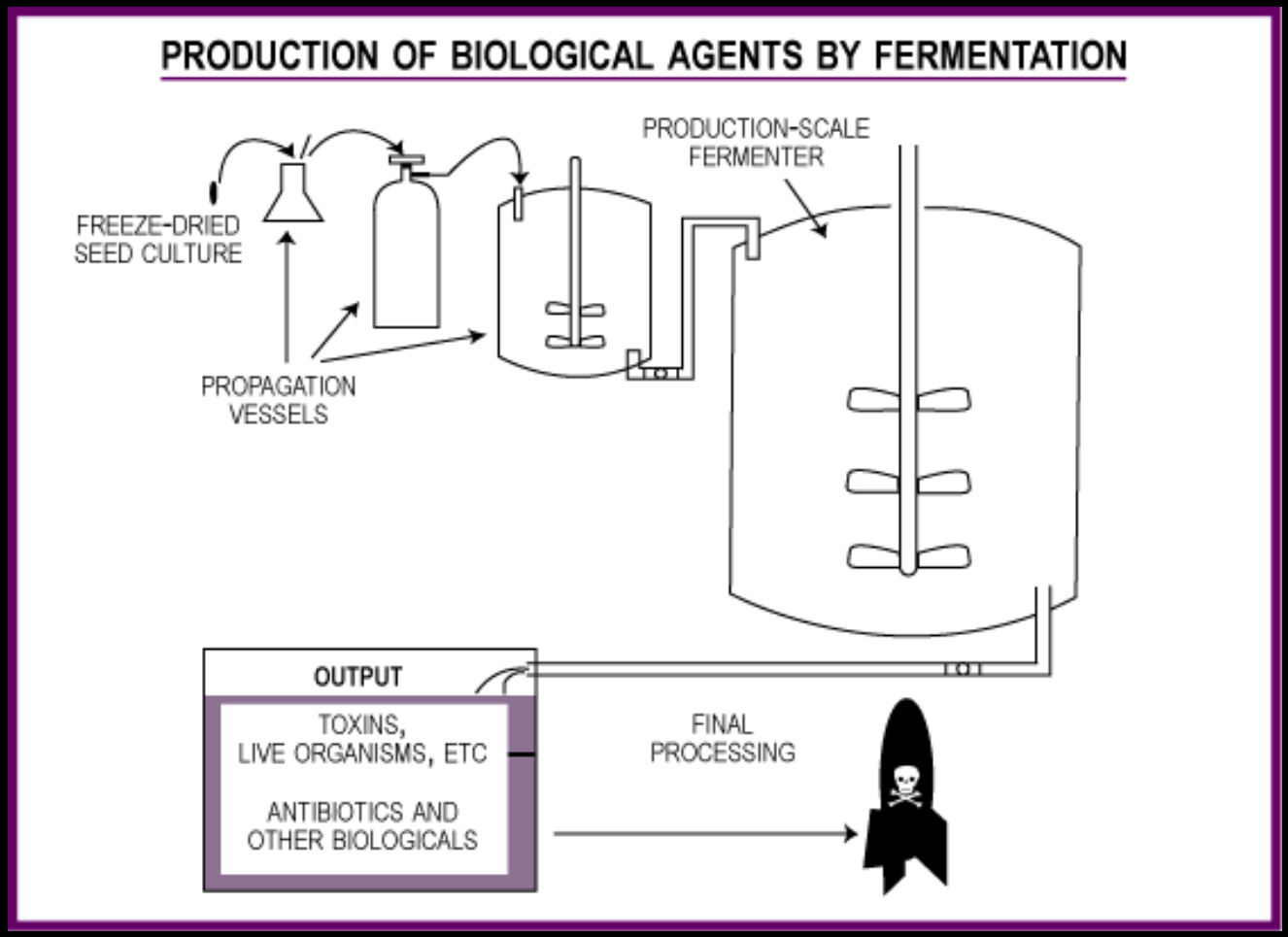
- Examples include emerging infectious diseases such as Nipah virus and hantavirus

- Most likely requires a concerted effort by a state-sponsored bio weapons program

Source: Centers for Disease Control, http://www.bt.cdc.gov/agent/agentlist-category.asp

OTHER KEY TERMS

- **Fermentation** – combining a small seed culture with nutrients to develop large quantities of biological agents.



OTHER KEY TERMS

- **Extraction/Physical Separation** – extracting small amounts of toxins (like ricin) from their living hosts (like castor beans or castor oil waste byproduct).

- **Synthetic Production** – Recombinant DNA techniques, like cloning toxic genes, implanting them into a suitable microbial host, and then using fermentation to produce significant quantities

- **Cultivation** – Growing viruses or parasites inside living cells (e.g., chick embryos, mouse brains) or in isolated cells within tissue culture.

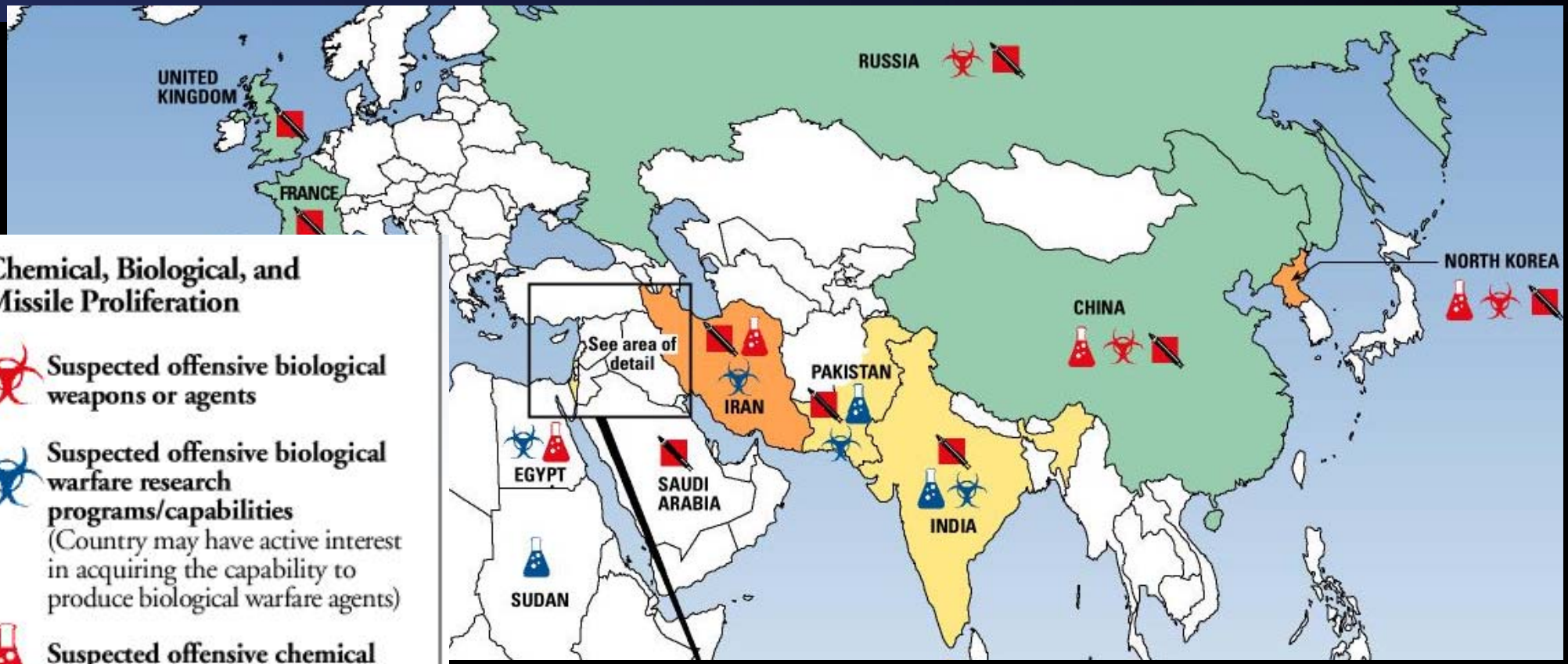
- **Vector** – a carrier which transfers an infectious organism from one host to another.

STATE BIOLOGICAL WEAPONS PROGRAMS

- Historical trajectory: early interest, ambitious programs, then international efforts to reverse the trend and constrain the proliferation and use of bio weapons in the future.

- Biological Weapons Convention
  - 176 countries have agreed to not develop, produce, stockpile, or acquire biological agents or toxins “of types and in quantities that have no justification for prophylactic, protective, and other peaceful purposes,” as well as weapons and means of delivery.
  - Countries that have not joined BWC include North Korea, Syria, Israel, Egypt, Angola, Cameroon, Chad, Djibouti, Eritrea, Guinea, Mauritania, Somalia, Tanzania, Haiti
  - China and Iran have signed BWC, but are suspected of having secret BW programs

PROLIFERATION OF CHEMICAL AND BIOLOGICAL WEAPONS



Chemical, Biological, and Missile Proliferation

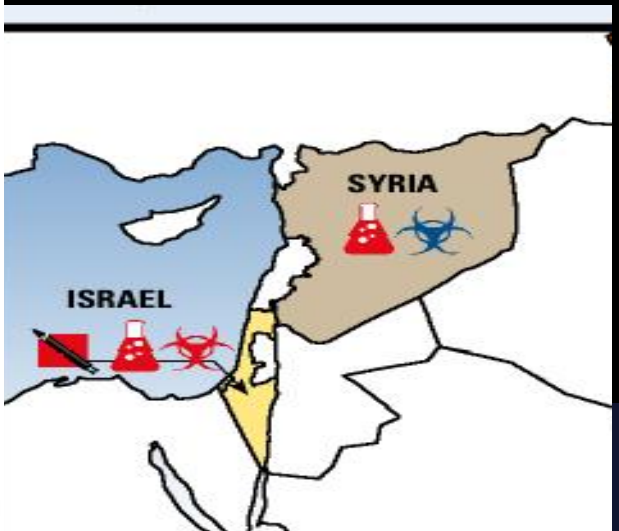
Suspected offensive biological weapons or agents

Suspected offensive biological warfare research programs/capabilities
(Country may have active interest in acquiring the capability to produce biological warfare agents)

Suspected offensive chemical weapons or agents
(Country may have some undeclared chemical weapons)

Suspected offensive chemical warfare research programs/capabilities
(Country may have active interest in acquiring or keeping the capability to produce chemical warfare agents)

Ballistic missiles exceeding 1,000-km range



Carnegie Endowment, 2009

CHALLENGES OF DETECTING BIOLOGICAL WEAPONS PROGRAMS

- More difficult “dual use” dilemma - but no precursor chemicals to monitor
- Detecting biological agent production is much more difficult than detecting chemical weapons production:
  - More potent by unit weight; need to produce much less
  - Biological agents can be rapidly produced
  - Facilities and equipment needed for developing biological weapons require a much smaller footprint
- Clandestine production of a small, yet potentially devastating, amount of a biological agent is thus easier

RICIN RECIPES

Supplies Needed:

Mason Jar
Castor Beans
Lye
Distilled Water
Gloves

Steps to take:

- Obtain some castor beans from a garden supply store.
  Put about 2 ounces of hot water into a glass jar and add a teaspoon full of lye. Mix it thoroughly.
- Wait for the lye/water mixture to cool
- Place 2 ounces of the beans into the liquid and let them soak for one hour.
- Pour out the liquid being careful not to get any on exposed skin . . .

http://ishare-world.blogspot.com/2008/02/why-people-want-to-know-how-to-make.html

RICIN RECIPES

- “Air tight jars, a blender, coffee filters, a basic pan and some newspaper” http://how-to.ask.com/make/how_to_make_ricin

- Castor beans http://gurneys.com/search.asp?eid=081506&ss=Castor+Bean&sid=504016&gclid=CJ7LtsL26qYCFRRg2godwxSOAg

- Lye http://candleandsoap.about.com/gi/o.htm?zi=1/XJ&zTi=1&sdn=candleandsoap&cdn=homegarden&tm=26&gps=331_333_1259_569&f=00&su=p504.1.336.ip_&tt=2&bt=1&bts=1&zu=https%3A//www.thelyeguy.com/store/store.php

- Acetone http://www.homedepot.com/h_d1/N-5yc1v/R-100141096/h_d2/ProductDisplay?langId=-1&storeId=10051&catalogId=10053

CONCLUSION

Biological agents:

- are more complicated than chemical weapons
- include bacteria, viruses, rickettsia, fungi and toxins; Category A biological agents are most severe, and include smallpox and anthrax
- are most desirable as weapons when they have a high capacity for small doses to cause lethal infections; a short incubation period; minimally contagious
- are considered by many to be the most insidious and indefensible type of weapons

"Biology is about to lose its innocence in a profound way. While Physics dominated weapons in the 20th century, Biology will dominate weapons in the 21st century."

– George Poste, former Head of R&D, SmithKline Beecham