

Risk Assessment and Risk Management

Laboratory Biosafety and Biosecurity Workshop

**Cairo, Egypt
3-5 April 2007**

www.biosecurity.sandia.gov

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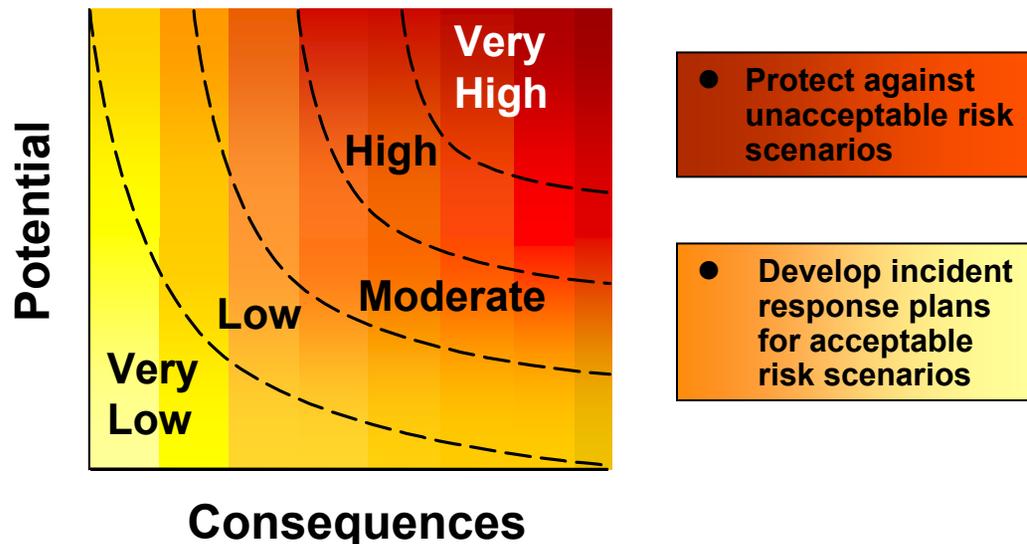
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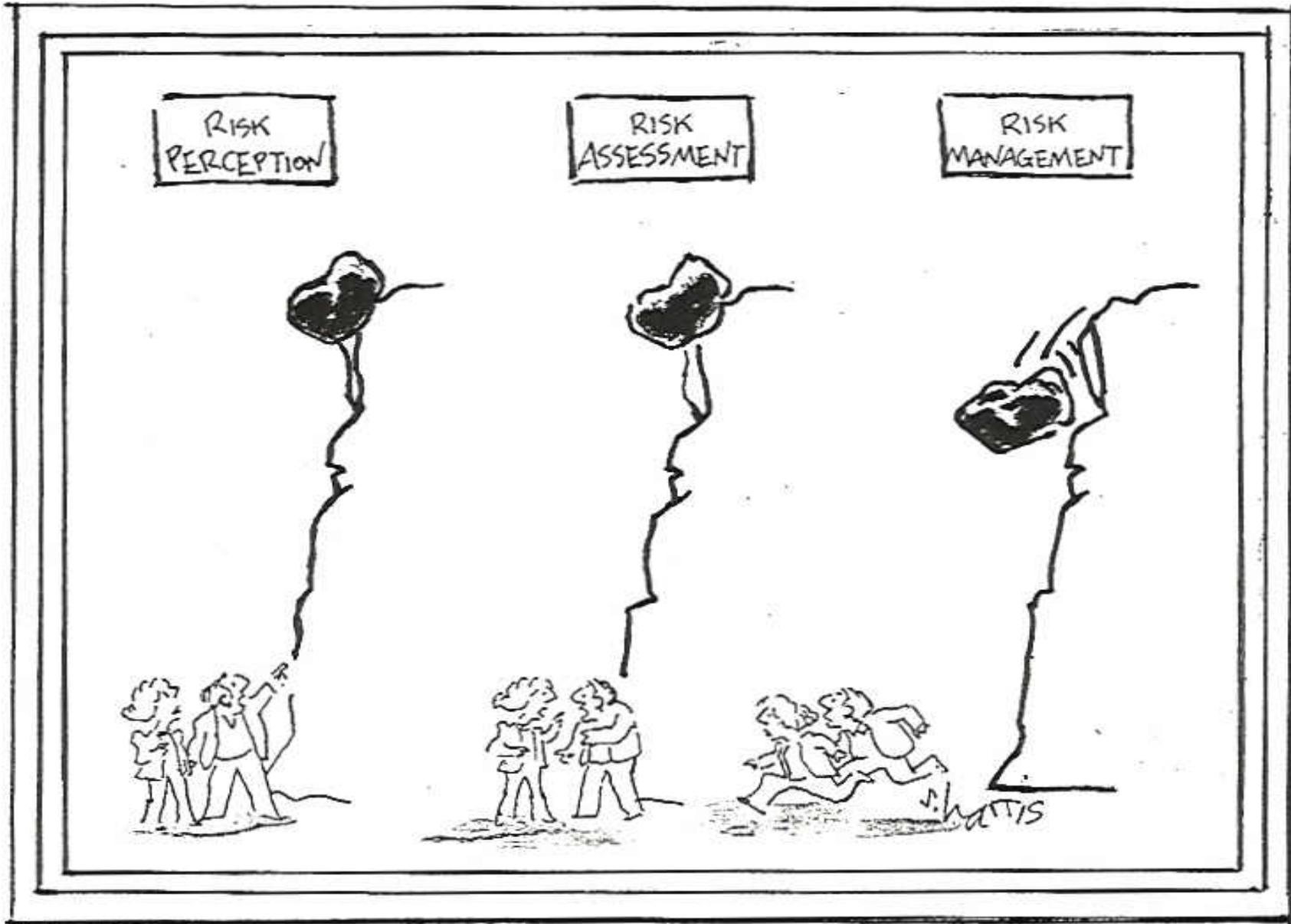
Risk

- **Is a function of the likelihood an adverse event will occur**
- **Laboratory work with pathogens will always involve some level of safety and security risk**
 - **Distinguish between “acceptable” and “unacceptable” risks**
 - **Cannot protect against every conceivable adverse event**
- **Resources for risk mitigation are not infinite**
 - **Existing resources should be used efficiently**

Biosecurity and Biosafety Based on Risk Management

- Most biological materials occur in nature and can be isolated from nature
- Critical not to compromise legitimate bioscience operations
 - Systems should be designed to address unique situations
- Management must distinguish between “acceptable” and “unacceptable” risks
 - Ensure that protection and the cost is proportional to the risk





Risk Perception in Laboratories

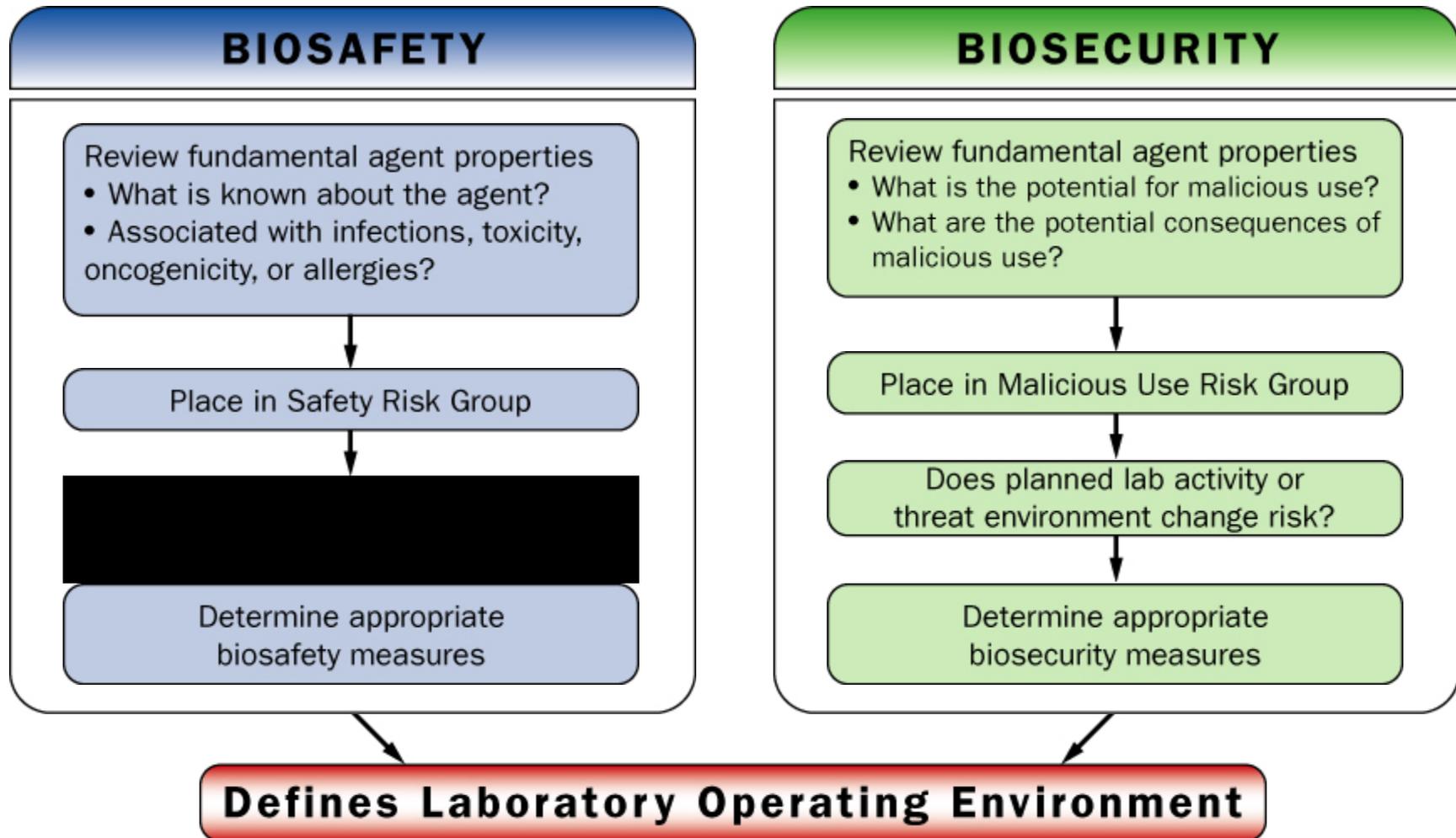
Biosafety risks: laboratory-acquired infections

- **History of lab-acquired infections**
 - Often attributed to carelessness or poor technique
 - Relatively few cases can be attributed to direct accident (mouth pipetting and sharps injuries)
 - Exposure to airborne pathogens generally presumed to be most plausible cause
 - Brucellosis is most common
- **Sporadic infections in community as a result**
 - 1973 and 1978—England had 3 secondary cases of smallpox
 - 1950—2 cases of Q fever in household of scientist
 - 1990—1 documented case of Monkey B virus from animal handler to wife
 - SARS—including 3 generations (9 cases)

Biosecurity risks: laboratories as sources of material for malicious use

- **Bioterrorism has emerged as a threat to international security**
 - 1984 Rajneeshee religious cult attacks
 - 1990s Aum Shinrikyo attempts
 - 2001 Anthrax attacks in the US
- **Examples of illicit acquisition**
 - 1990s—Aum Shinrikyo ordered *Clostridium botulinum* from a pharmaceutical company
 - 1995—Larry Wayne Harris, a white-supremacist, ordered 3 vials of *Yersinia pestis* from the ATCC
 - 1995—Laboratory technician Diane Thompson removed *Shigella dysenteriae* Type 2 from hospital's collection and infected co-workers

Risk Assessment: Integrated Biosafety and Biosecurity

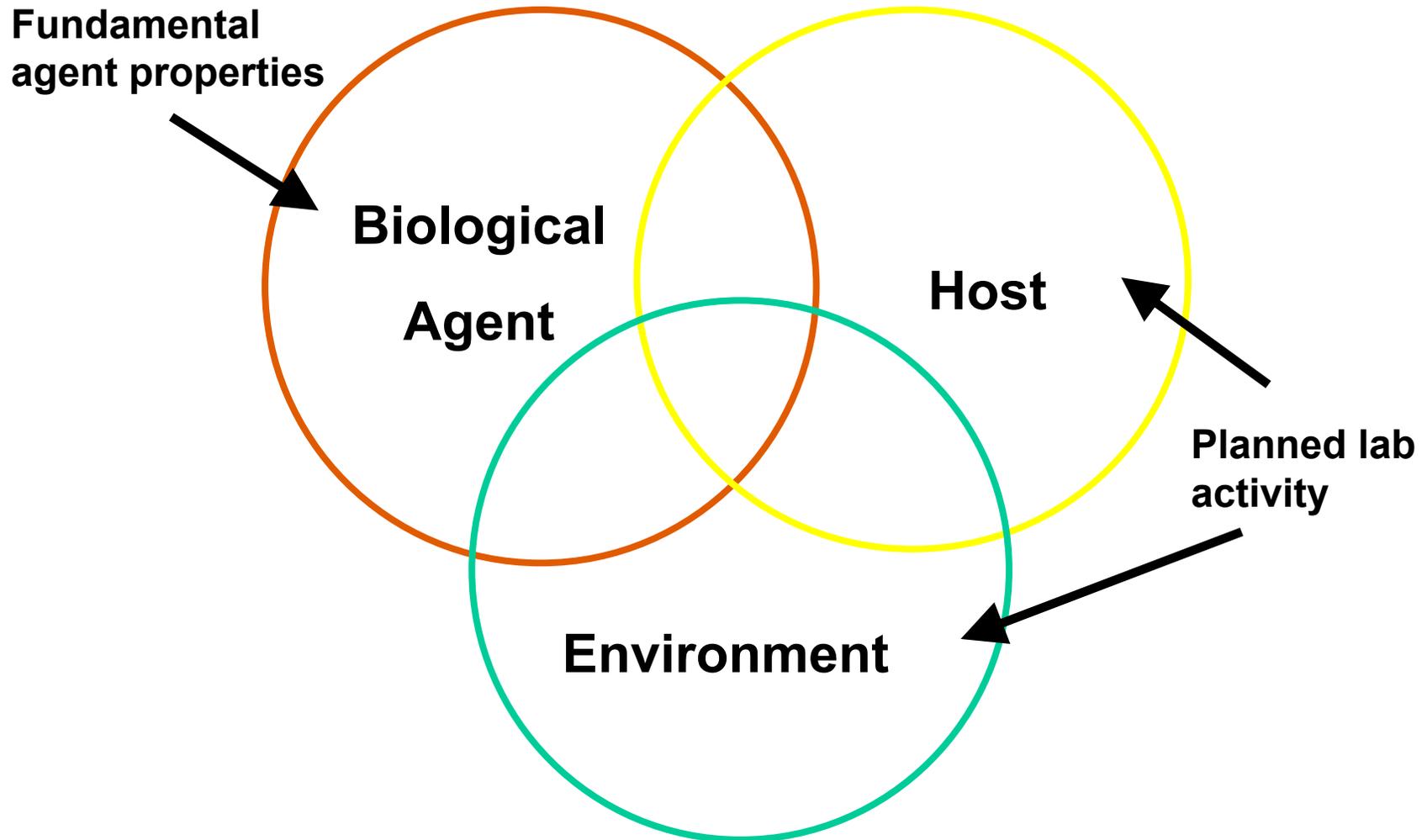


Risk Assessment

- **Enables the professional (e.g. biosafety officer, responsible official) to:**
 - **Become familiar with the proposed work activities (procedures, equipment, personnel)**
 - **Be a knowledgeable and credible partner with the investigator to develop a safe and secure environment for the work**

- **Review all activities associated with infectious materials**
 - **Proposed work activities**
 - **Personnel**
 - **Storage**
 - **Transfer and transport**
 - **Destruction**

Biosafety Risk Assessment



Biosafety Risk Assessment: Safety Risk Group Evaluation

- **What is known about the agent?**
 - **Pathogenicity – ability to cause disease**
 - **Virulence – degree of pathogenicity**
 - **Host range – restricted or broad, human, animals, plants**
 - **Communicability – are there reports of epidemics? Of laboratory infections?**
 - **Transmission – means (e.g. direct contact, vector borne) and routes (e.g. ingestion, inhalation)**
 - **Environmental stability – e.g. resistance to disinfection**
- **Additional agent factors:**
 - **Toxicity**
 - **Is the agent associated with cancer (e.g. Hepatitis B virus associated with liver cancer)?**
 - **Does the agent or by-products induce allergic reactions (e.g. Penicillin)?**

Biosafety Risk Assessment: Safety Risk Groups

- **Risk Group 1**
 - No or low individual and community risk
 - Unlikely to cause human or animal disease
- **Risk Group 2**
 - Moderate individual risk, low community risk
 - Can cause disease but unlikely to be a serious hazard. Lab exposures may cause serious infection, but effective treatment and preventative measures are available and risk of spread of infection is limited
- **Risk Group 3**
 - High individual risk, low community risk
 - Usually causes serious human or animal disease but does not ordinarily spread. Effective treatment and preventative measures are available.
- **Risk Group 4**
 - High individual and community risk
 - Usually causes serious human or animal disease and can be readily transmitted. Effective treatment and preventative measures are not usually available



Safety Risk Group Examples

- **Risk Group 1**

- ***Bacillus subtilis***

- Ubiquitous bacterium found in water, soil, air
- Not considered pathogenic or toxigenic to humans, animals, or plants

- ***Escherichia coli* K-12**

- E. coli is normal inhabitant of colon of almost all mammals
- K-12 is debilitated strain – does not normally colonize human intestine
- History of safe commercial use

- **Risk Group 2**

- **Measles virus**

- Pathogenicity: acute disease, fatality <0.5% - 25%
- Host range: Humans
- Transmission: primarily droplet spread
- Vaccine available

- **Hepatitis B virus**

- Pathogenicity: asymptomatic and symptomatic infections, long-term fatality = 2-3%, 95% of adult infections self-limiting
- Host range: Humans (chimpanzees are susceptible)
- Vaccine available

Safety Risk Group Examples

- **Risk Group 3**

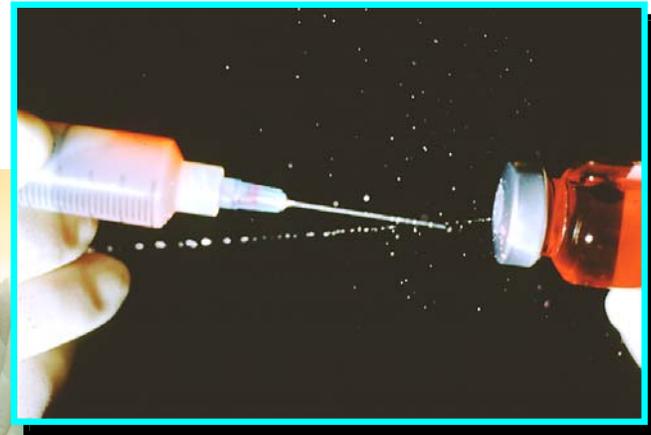
- ***Mycobacterium tuberculosis***
 - Proven hazard to laboratory workers (3x higher rate of infection)
 - Low aerosol infectious dose (ID₅₀ < 10 bacilli)
 - Host range: Primarily humans, cattle, primates, other animals (rodents)
- **St. Louis encephalitis virus**
 - Pathogenicity: Fatality rate of 2-22%, 30-50% of severe cases have prolonged convalescence
 - Host range: Humans, wild birds, other mammals
 - Supportive care is only treatment

- **Risk Group 4**

- **Ebola virus**
 - Pathogenicity: Sudden onset, 50 – 90 % fatality
 - Host range: Humans, monkeys, chimpanzees, domestic guinea pigs
 - BSL4 laboratory recommended even for clinical work (Public Health Agency of Canada)

Biosafety Risk Assessment: Elements That May Modify Risk

- **Does the environment or activity change the risk?**
 - **Lab vs. field studies**
 - **Animal studies?**
 - **Procedures**
 - Does planned experiment have the potential to generate aerosols?
 - **Equipment**
 - **Needles**
 - **Centrifuges**
 - **Homogenizers**
 - **Pipettes**

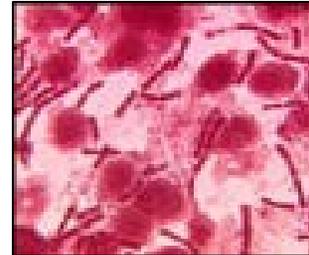


Biosafety Risk Assessment: Elements That May Modify Risk

- **Are there host factors that change the risk?**
 - **Deficiencies in host defenses**
 - Pre-existing medical conditions – for example:
 - Asplenia, eczema
 - **Reproductive hazards**
 - Pregnancy, teratogens, mutagens – for example:
 - Rubella, Toxoplasma, Chlamydia
 - **Allergies**
 - Foreign proteins, vaccine constituents, antimicrobial therapies – for example:
 - Animal dander, egg proteins, latex
 - **Immunization status**
 - Immunization against workplace pathogens but ...
 - Not always the answer (vaccine efficacy, safety issues)
 - **Behavioral elements**
 - Education, training, experience, motivation, attentiveness

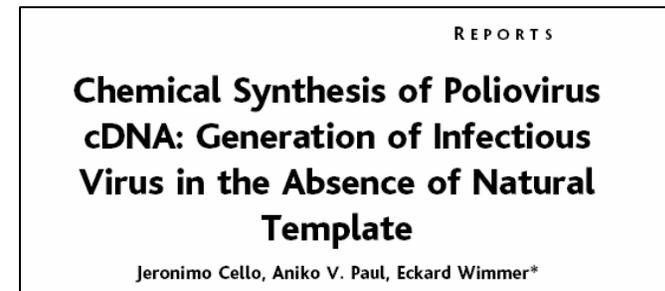
Biosecurity Risk Assessment

- 1. Evaluate assets (agent assessment)**
- 2. Evaluate lab activity**
- 3. Evaluate threat environment**

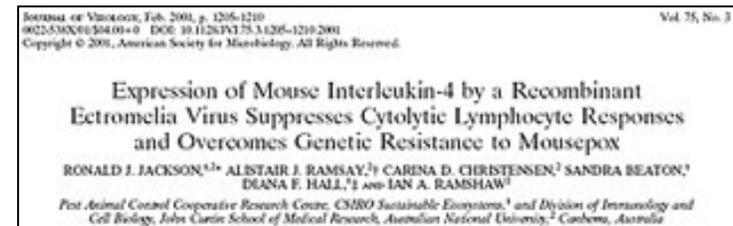


Biosecurity Risk Assessment: Malicious Use Risk Group Evaluation

- **Assess value of the agents from an adversary's perspective**
 - **Consequences**
 - **Population**
 - Transmissibility
 - Mortality
 - Morbidity
 - **Economic**
 - **Psychological**
 - **Weaponization potential**
 - **Acquisition**
 - Natural
 - Laboratory
 - Synthetic biology
 - **Production**
 - R&D
 - Covert production
 - Ease of storage
 - **Dissemination**
 - Route of infection (e.g. aerosol, ingestion)
 - Environmental hardiness



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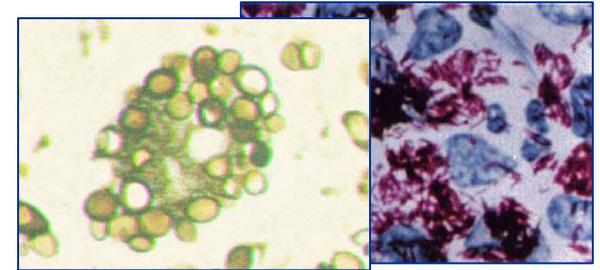
Biosecurity Risk Assessment: Malicious Use Risk Groups

- **Nonpathogenic**
 - Malicious use would have insignificant or no consequences
- **Low**
 - Difficult to deploy, and/or
 - Malicious use would have few consequences
- **Moderate**
 - Relatively difficult to deploy, and
 - Malicious use would have localized consequences with low to moderate casualties and/or economic damage, and potentially cause pervasive anxiety
- **High**
 - Not particularly difficult to deploy, and
 - Malicious use could have national or international consequences, causing moderate to high casualties and/or economic damage, and the potential to cause mass panic and significant social disruption
- **Extreme**
 - Would normally be classified as highly attractive, except that they are not found in nature (eradicated)
 - Could include genetically engineered agents, if they would otherwise be classified as highly attractive



Malicious Use Risk Group Examples

- **Nonpathogenic**
 - *Bacillus cereus, Lactobacillus acidophilus, Saccharomyces cerevisiae*
- **Low Malicious Use Risk (LMUR)**
 - *Mycobacterium leprae*
 - Consequences: Not highly virulent, not highly contagious, completely curable
 - Weaponization potential: Production is a significant challenge, not environmentally hardy
- **Moderate Malicious Use Risk (MMUR)**
 - *Coccidioides immitis*
 - Consequences: Not contagious, 5-10 out of every 1000 infected develop life-threatening infection
 - Weaponization potential: Requires technical skills to handle safely, easy to procure virulent strain, easy to grow

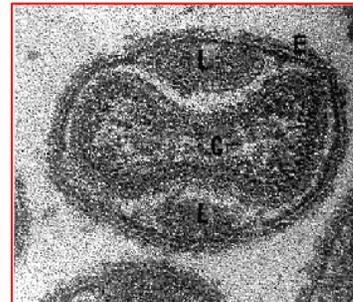


Coccidioides immitis

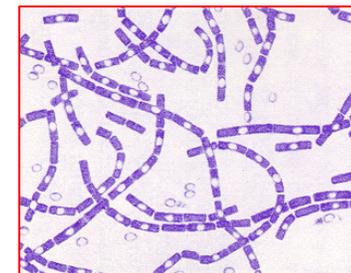
Mycobacterium leprae

Malicious Use Risk Group Examples

- **High Malicious Use Risk (HMUR)**
 - *Bacillus anthracis*
 - Consequences: High fatality rate, not contagious, early diagnosis is difficult
 - Weaponization potential: History of malicious use, wide endemic area (but many less virulent strains), very stable, easy to grow and produce spores
- **Extreme Malicious Use Risk (EMUR)**
 - *Variola major virus*
 - Consequences: High fatality rate, contagious, few vaccinated
 - Weaponization potential: History of weaponization, very stable, difficult to obtain



Variola major



Bacillus anthracis

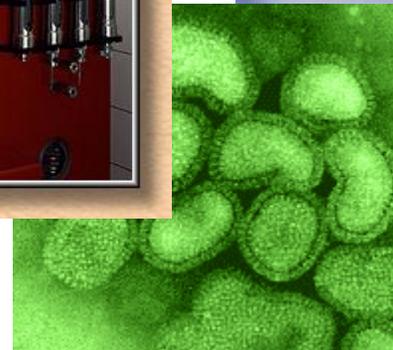
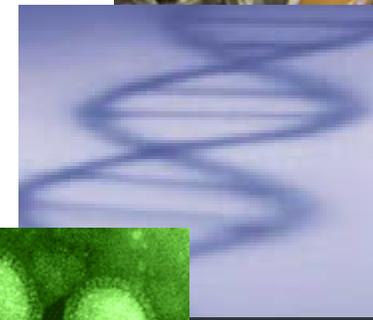
Biosecurity Risk Assessment: Other Assets at Biological Facilities

- **Security Information or Systems**
 - May be targeted to facilitate gaining access to dangerous biological materials

- **Other Facility Assets**
 - May be targeted by political extremists, disgruntled employees, etc.
 - May include:
 - High containment laboratories
 - Animals

Biosecurity Risk Assessment: Elements That May Modify Risk

- Consider lab experiment
 - Does planned experiment produce an agent with higher weaponization potential or higher potential consequences?
 - For example: Increased stability, GMOs, large quantities, aerosol challenges

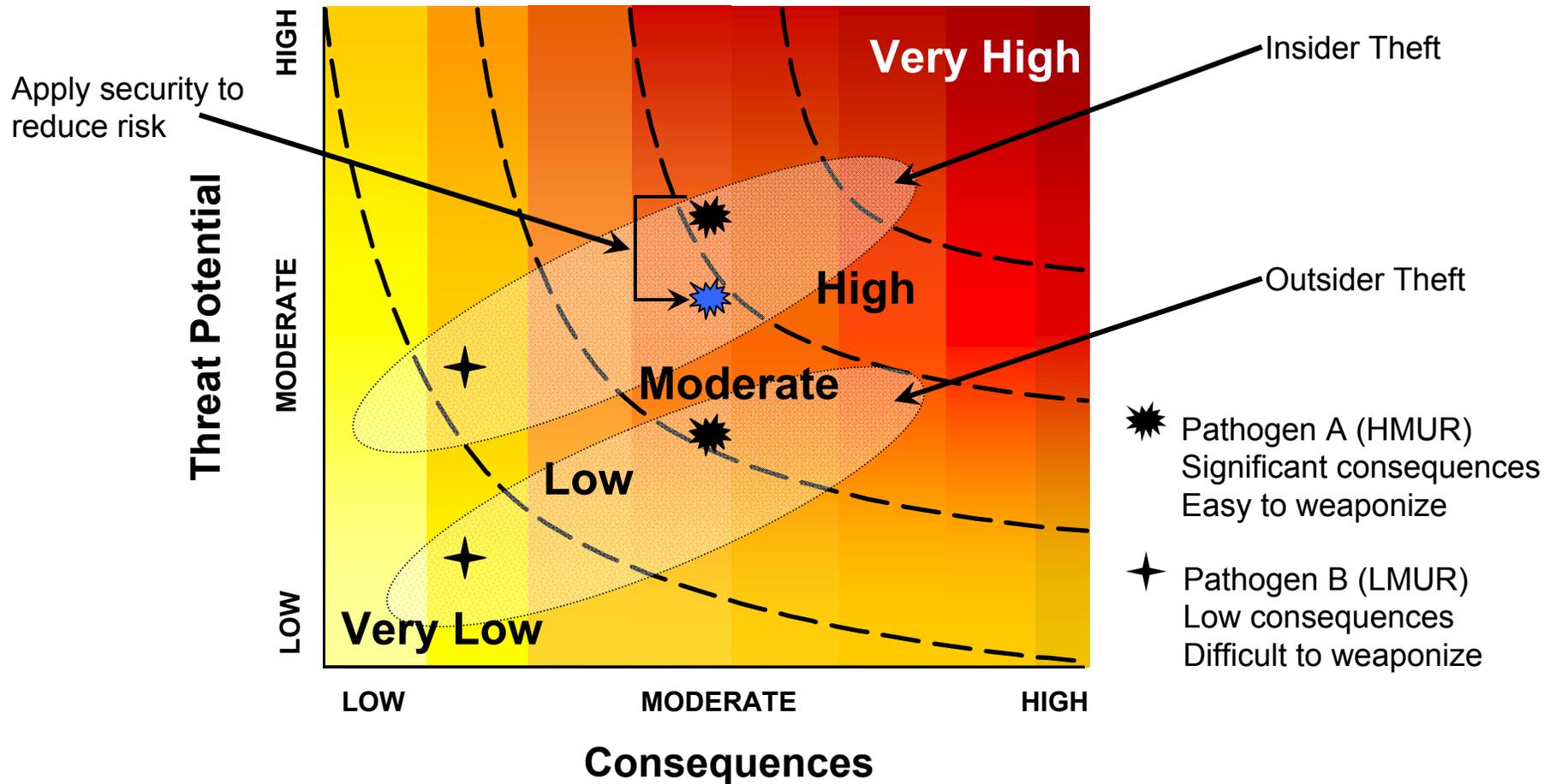


Biosecurity Risk Assessment: Elements That May Modify Risk

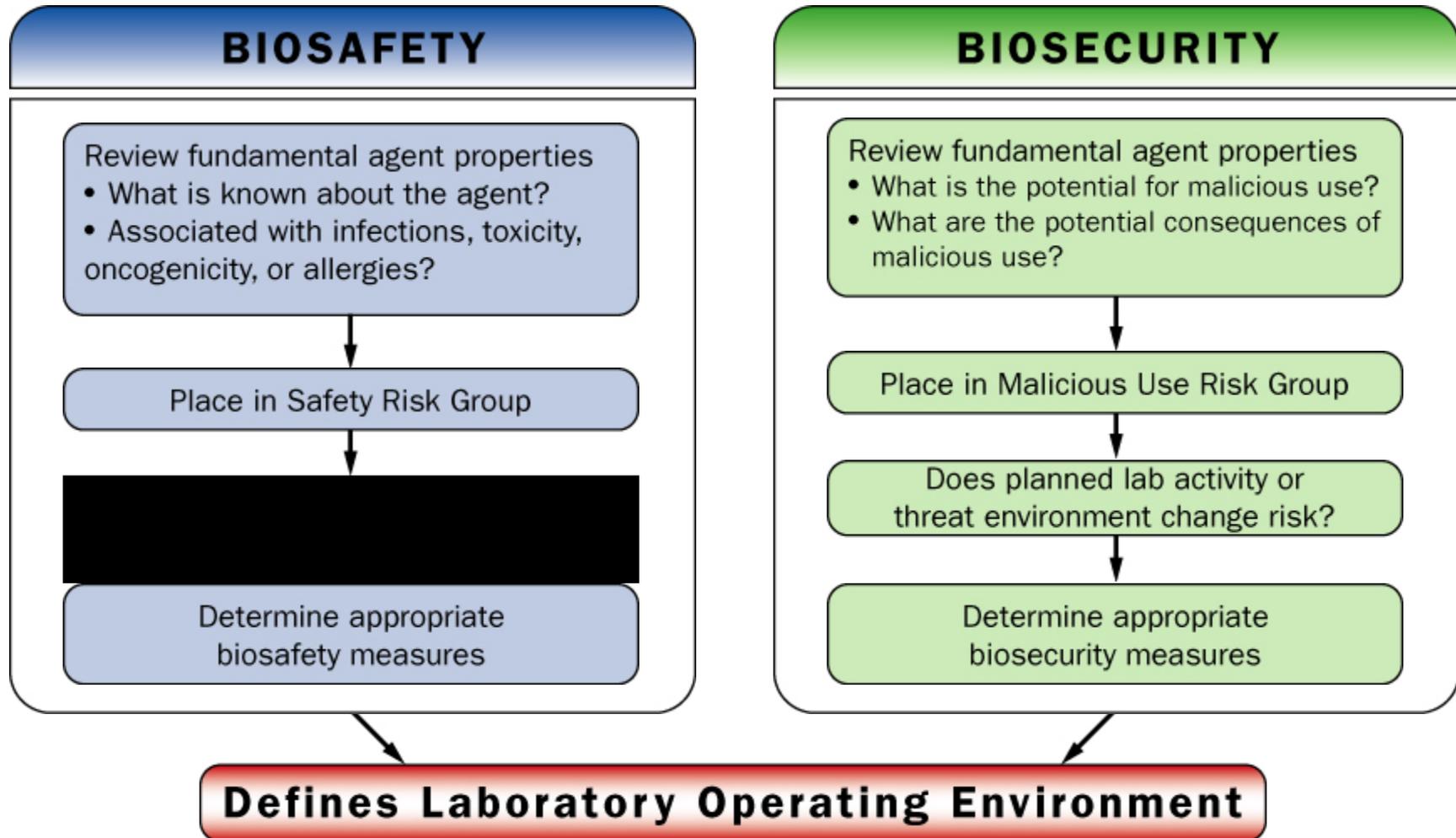
- **Adversary Classes**
 - Terrorist
 - Extremist
 - Criminal
- **Insiders**
 - Authorized access to the facility, dangerous pathogens, and/or restricted information
 - Distinguish Insiders by level of authorized access
 - Site
 - Building
 - Asset
 - Facility management, site security, and local law enforcement interviews
- **Outsiders**
 - No authorized access
 - Local law enforcement, site security, and intelligence community interviews



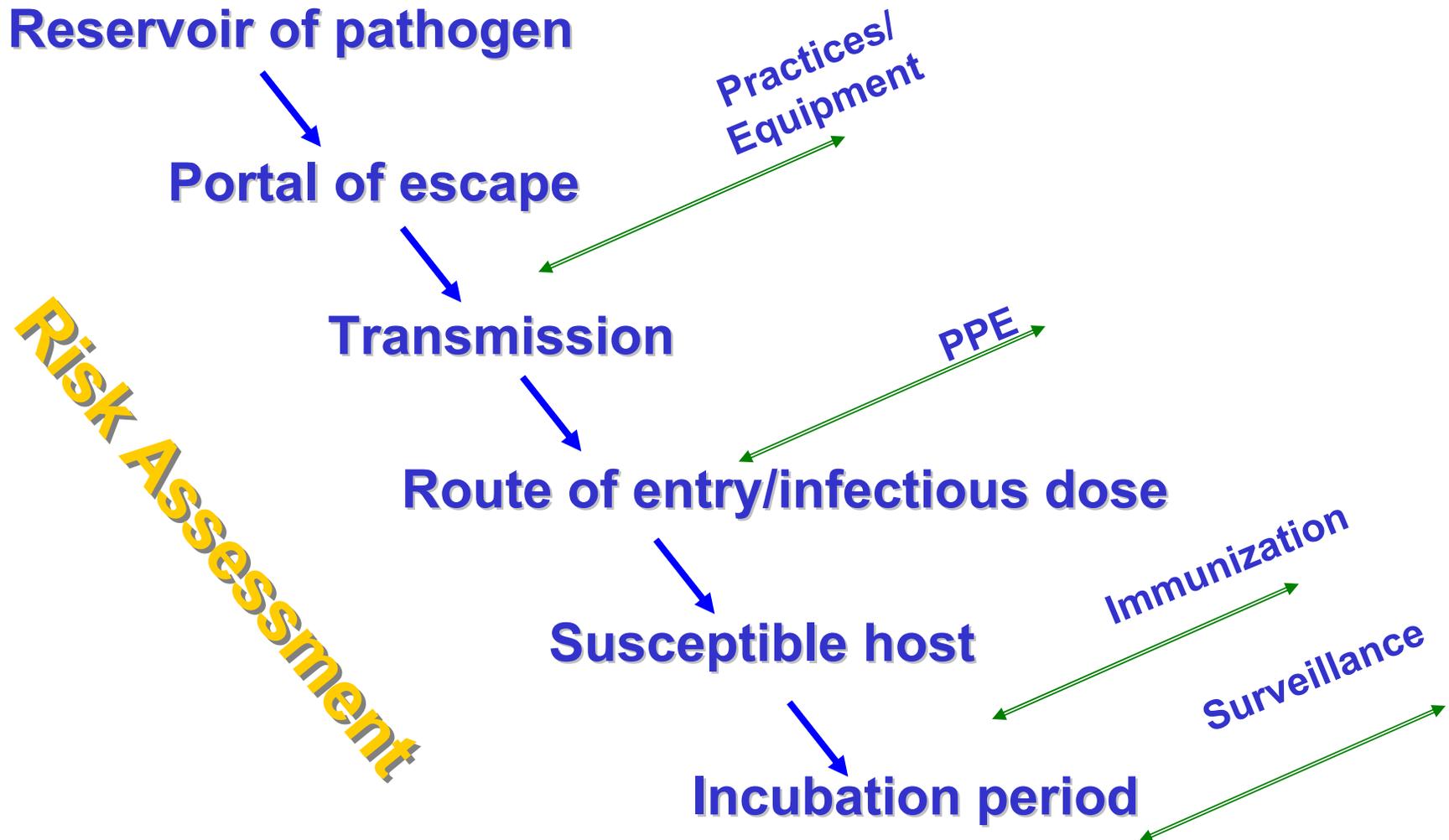
Biosecurity Risk: Insider vs. Outsider Threat



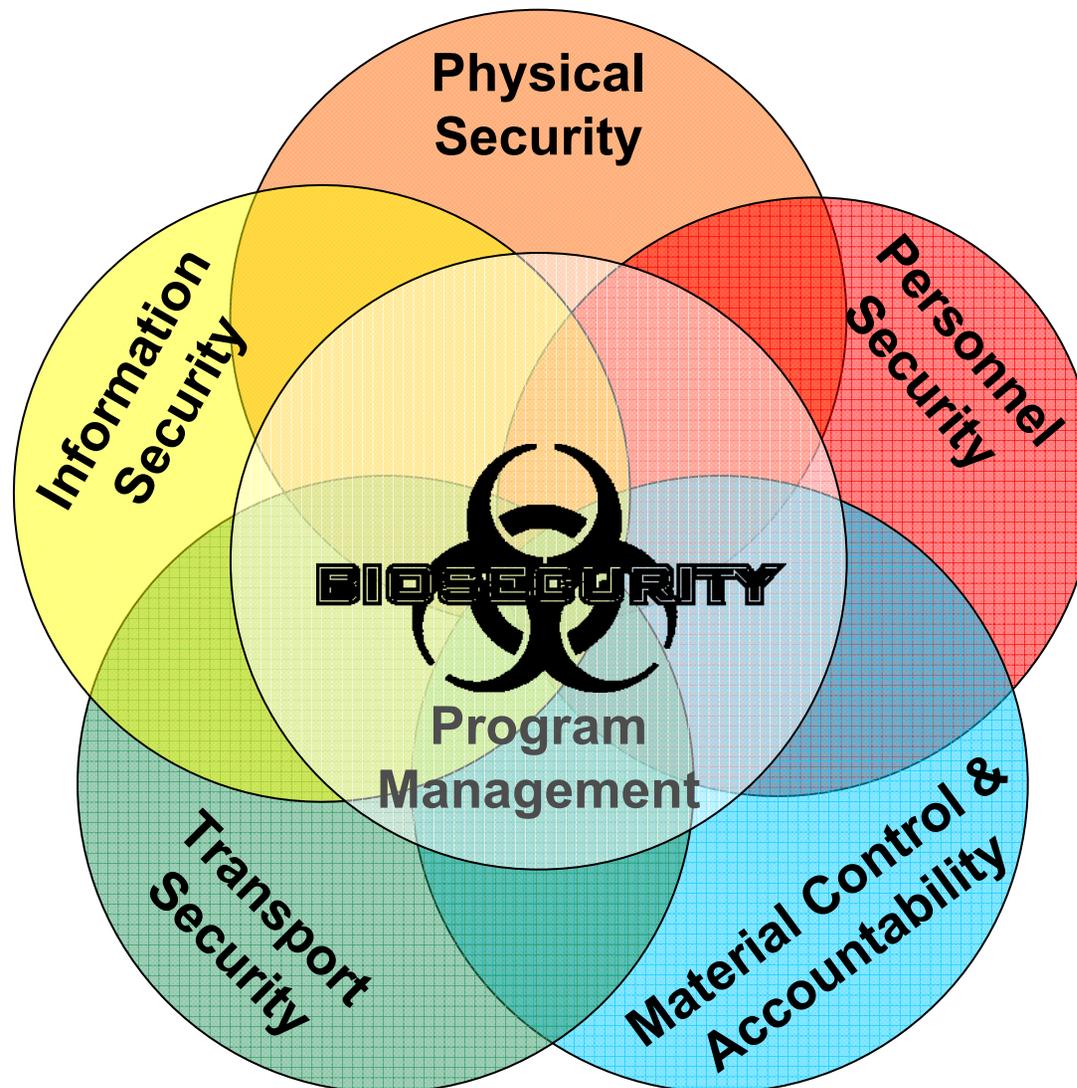
Integrated Biosafety and Biosecurity



Risk Management: Implementation of Biosafety



Risk Management: Implementation of Biosecurity



Conclusions

- **Need to integrate biosafety and biosecurity considerations into decisions about laboratory operations**
- **Biological facility risk assessment provides an opportunity to concentrate resources on the highest risks**
 - **Tiered system of protection based on risk assessment and risk management methodologies**
- **Parallels exist between safety and security risk assessment processes**