

A tall, thin clock tower with a golden dome at the top, silhouetted against a bright sky. It stands behind a building with a red-tiled roof and some greenery.

# LABORATORY BIOSAFETY

LOUISIANA STATE UNIVERSITY  
OFFICE OF  
ENVIRONMENTAL HEALTH & SAFETY

# BIOSAFETY VS. BIOSECURITY

- ❖ Biosafety: reducing or eliminating exposure of individuals and the environment to potentially-hazardous biological agents
- ❖ Biosecurity: protection of microbial agents from loss, theft, diversion, or intentional misuse

# **BIOSAFETY**

- ❖ Biosafety is achieved by implementing various degrees of laboratory controls and containment; through laboratory design and access restrictions, personnel expertise and training, use of specialized containment equipment, and safe methods of managing infectious materials in a laboratory setting.



# BIOSECURITY

- ❖ Biosecurity is achieved by limiting access to facilities, research materials, and information.



# **BIOSAFETY AND BIOSECURITY SHARE COMMON COMPONENTS**

- ❖ Both are based on:
  - Risk Assessment
  - Personnel Expertise & Responsibility
  - Control & Accountability for Research Materials
  - Access Control
  - Material Transfer Documentation
  - Training
  - Emergency Planning
  - Program Management

# CENTERS FOR DISEASE CONTROL (CDC) & THE NATIONAL INSTITUTES OF HEALTH (NIH) GUIDELINES

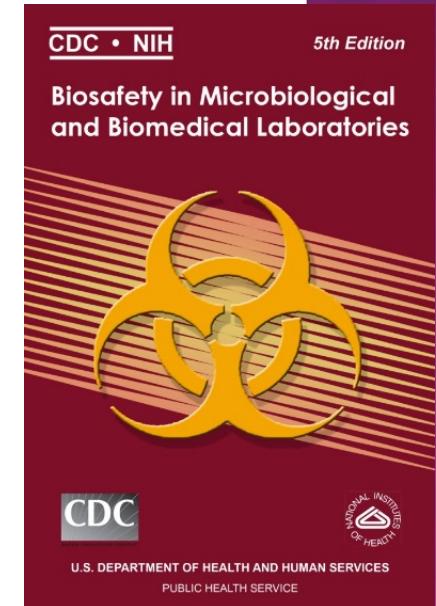
- ❖ Laboratorians recognize the hazards of processing infectious agents.
- ❖ Regulations outline precautions, special practices, and decontamination procedures.
- ❖ Guidelines have been developed to protect workers in microbiological and medical labs through engineering controls, management policies, and work practices.

# CDC & NIH GUIDELINES

- ❖ **COMPLETE** information and recommendations can be found in *Biosafety in Microbiological and Biomedical Laboratories 5th Edition* and the *NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules*

<http://www.cdc.gov/biosafety/publications/bmbl5/>

<https://osp.od.nih.gov/biotechnology/nih-guidelines/>



# CDC & NIH GUIDELINES: PRIMARY BARRIERS & UNIVERSAL PRECAUTIONS

- ❖ **Primary Barriers:** physical barriers or personal protective equipment between lab worker and pathogen
  - Biological safety cabinets, special breathing apparatuses, etc.
- ❖ **Universal Precautions:** set of guidelines that is aimed at preventing the transmission of blood-borne pathogens from exposure to blood and other potentially infectious materials.
  - originally developed to protect health professionals
  - Also apply in a clinical setting
  - May also be important for field epidemiology practices during an outbreak investigation (i.e., collecting lab specimens)

# UNIVERSAL PRECAUTIONS

- ❖ Include: hand hygiene, gloves, gowns, masks, eye protection, face shields, and use of safe sharps practices
- ❖ Require that all equipment or contaminated items are handled to prevent transmission of infectious agents
- ❖ Special circumstances may require additional precautions
  - Additional protective clothing or special site decontamination
  - Ex: CoVID19 Pandemic

# LAB PRACTICES & TECHNIQUES

- Strict adherence

- Standard microbiological practices and techniques

- Workers must be

- Aware of potential hazards
  - Trained
  - Proficient in safe practices & techniques

- Appropriate training

# **BIOSAFETY MANUAL**

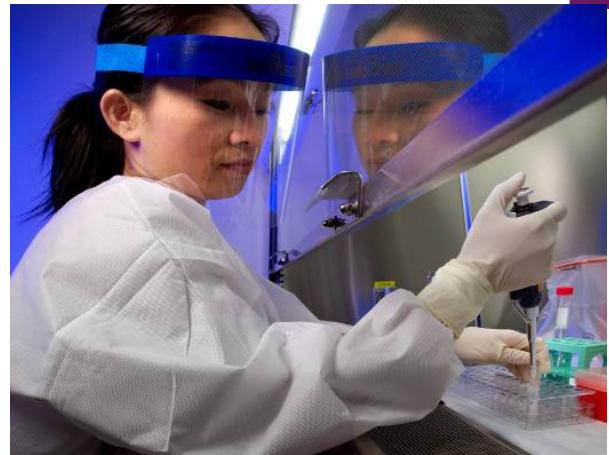
- Developed specifically for each laboratory
  - Identifies hazards
  - Specifies practices & procedures to minimize or eliminate these hazards
- Required reading
- Laboratory personnel
  - Responsible for work conducted in laboratory
  - Trained & knowledgeable in techniques, safety procedures, and associated hazards

# SAFETY EQUIPMENT

- Specialized equipment for a lab that provides protection to the worker from hazardous agents
  - Contains infectious splashes, splatters, aerosols
  - EX: biosafety cabinets (BSC), enclosed containers and safety caps on centrifuge buckets.
- Engineering controls- protect workers by removing hazardous conditions or placing a physical barrier between the worker and the hazard
  - Protect lab personnel
  - Protect environment
  - Prevent contamination of materials

# SAFETY EQUIPMENT

- Personal protection equipment (PPE)
  - Gloves
  - Coats, gowns, sleeve covers
  - Boots, shoe covers
  - Respirators
  - Face shields, goggles, safety glasses
- Used with BSCs or as primary barrier



# SECONDARY BARRIERS

- Facility design and construction
  - Laboratory worker protection
  - Protect persons outside lab
  - Protects community/environment
- Recommended barriers
  - Depends on transmission of agents
  - Ex: Handwashing sinks, eye wash stations, safety showers, specialized decontamination facilities, specialized ventilation systems.

# CDC & NIH GUIDELINES

- ❖ Labs are divided into 4 biosafety levels; protective practices increase with each level.



# **BIOSAFETY LEVELS**

- Assignment of Biosafety Levels (BSL)
  - Lab practices and techniques
  - Safety equipment
  - Laboratory facilities
- Determined by risk assessment
- Established by responsible staff



# BSL-1

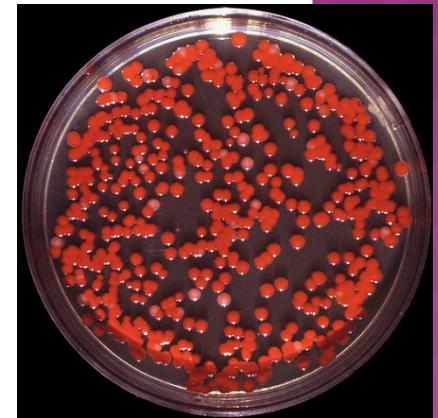
- Type of laboratory

- Research, student training, and teaching labs
- Well-defined and characterized agents
  - No harm to healthy humans



- Examples

- *Bacillus subtilis*
- *Naegleria gruberi*
- Exempt organisms under NIH guidelines



# BSL-1

- Basic level of containment
  - Use of gloves and lab coats
- Relies on
  - Standard microbiological practices
  - No special primary or secondary barriers
    - Handwashing sinks are required

# BSL-2

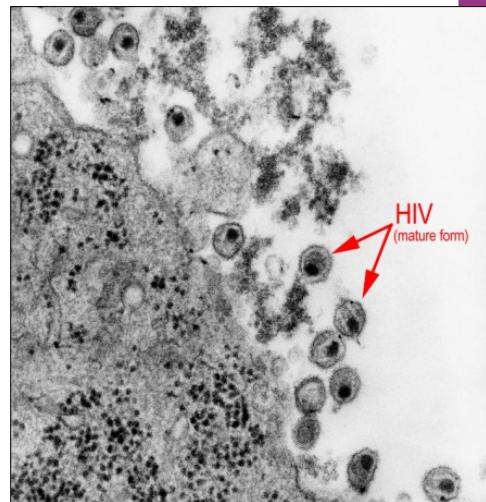
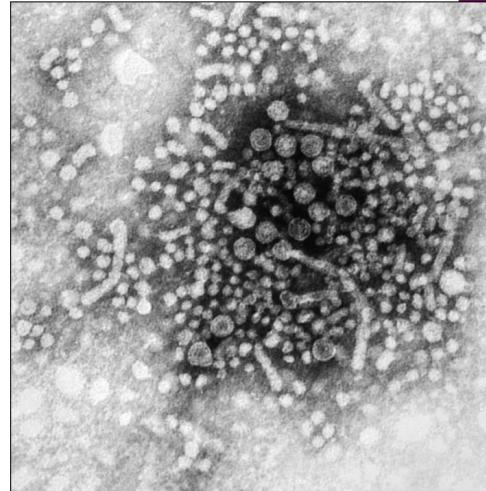
## ○ Type of laboratory

- Research, clinical, diagnostic, and teaching labs
- Work with indigenous, moderate-risk agents associated with human disease
- Relies on standard microbiological techniques
- Employ techniques to reduce the probability of splashes and aerosols
- Biological safety cabinet

# BSL-2

## ○ Examples

- Hepatitis B virus
- HIV
- *Mycobacterium leprae*
- *Salmonella typhimurium*
- Primate or human-derived blood, body fluid, tissue or cell lines where the presence of an infectious agent is unknown



# BSL-2

## ○ Primary hazards

- Percutaneous or mucous membrane exposure
- Ingestion
- Contaminated needles or other sharps
- Possible Inhalation

## ○ Primary and secondary barriers

- Personal protective equipment
  - Lab coat, close toed shoes, gloves, safety glasses
- Biological safety cabinet
  - Reduce probability of splashes and aerosols when working with potentially infectious material

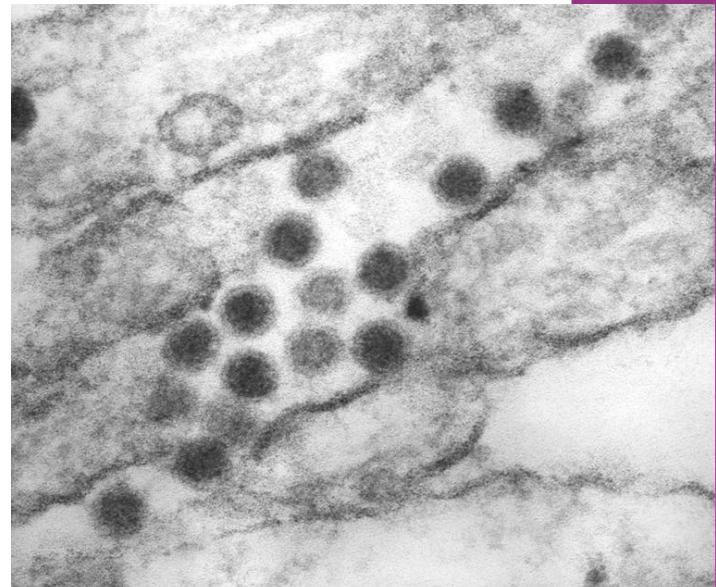
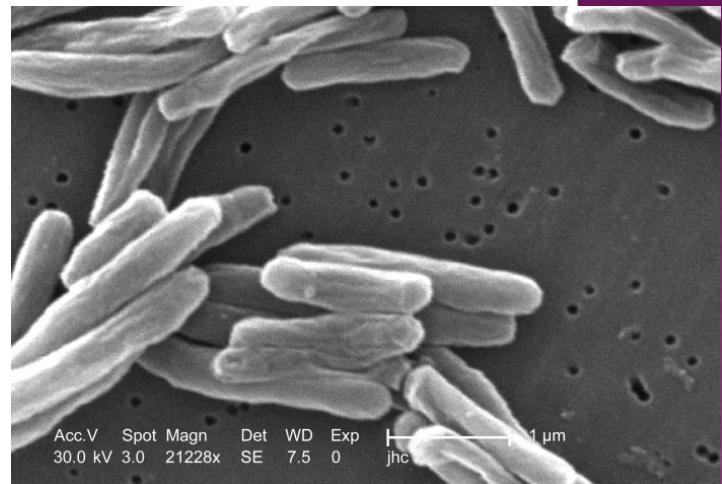
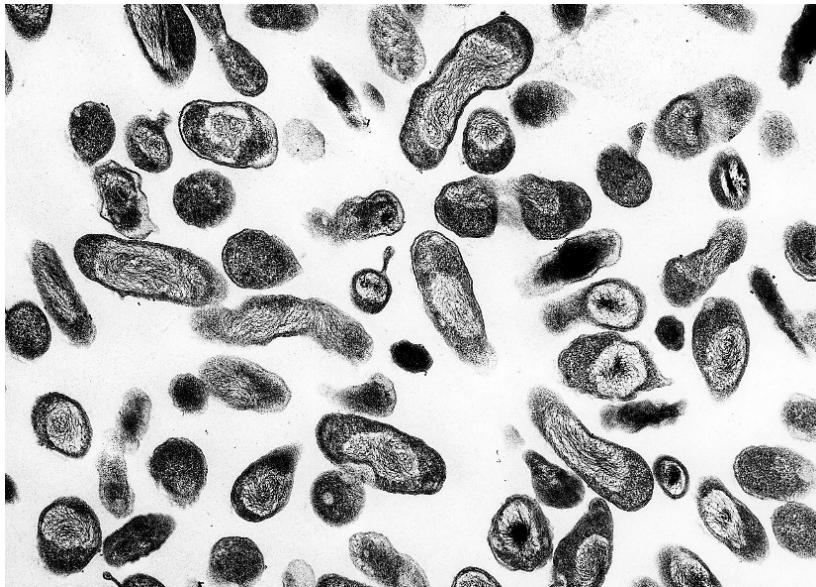
# BSL-3

- Type of laboratory
  - Clinical, teaching, research, or production facilities
    - Indigenous or exotic agents
    - High potential for respiratory transmission
- May cause serious and potentially lethal infection

# BSL-3

## ○ Examples

- *Mycobacterium tuberculosis*
- St. Louis encephalitis
- *Coxiella burnetii*



# BSL-3

## ○ Primary hazards

- Exposure to infectious aerosols
- Autoinoculation
- Ingestion

## ○ Primary and secondary barriers

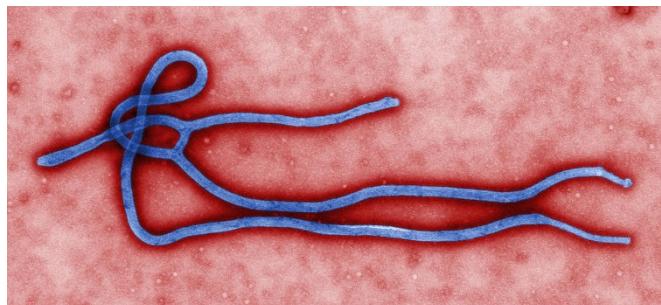
- Biosafety cabinets
- Personal protective equipment
  - Includes personal respiratory protection
- Controlled access to the lab
- Specialized ventilation and waste disposal systems



# BSL-4



- Required for work with dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections and life-threatening disease that is frequently fatal, for which there are no vaccines or treatments, or a related agent with unknown risk of transmission
- Examples
  - Ebola virus
  - Marburg virus



# BSL-4

## ○ Primary hazards

- Exposure to infectious aerosols
- Mucous membrane or broken skin exposure to infectious droplets
- Autoinoculation

## ○ Primary and secondary barriers

- Full body air supplied positive pressure personal suit
- Facility is generally in a separate building or completely isolated zone with controlled access
- Specialized ventilation and waste disposal system



# BMBL SUMMARY OF RECOMMENDED BIOSAFETY LEVELS FOR INFECTIOUS AGENTS

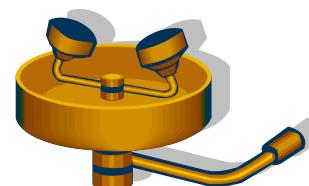
BSL	Agents	Practices	Primary Barriers and Safety Equipment	Facilities (Secondary Barriers)
1	Not known to consistently cause diseases in healthy adults	Standard microbiological practices	<ul style="list-style-type: none"> <li>■ No primary barriers required.</li> <li>■ PPE: laboratory coats and gloves; eye, face protection, as needed</li> </ul>	Laboratory bench and sink required
2	<ul style="list-style-type: none"> <li>■ Agents associated with human disease</li> <li>■ Routes of transmission include percutaneous injury, ingestion, mucous membrane exposure</li> </ul>	BSL-1 practice plus: <ul style="list-style-type: none"> <li>■ Limited access</li> <li>■ Biohazard warning signs</li> <li>■ "Sharps" precautions</li> <li>■ Biosafety manual defining any needed waste decontamination or medical surveillance policies</li> </ul>	Primary barriers: <ul style="list-style-type: none"> <li>■ BSCs or other physical containment devices used for all manipulations of agents that cause splashes or aerosols of infectious materials</li> <li>■ PPE: Laboratory coats, gloves, face and eye protection, as needed</li> </ul>	BSL-1 plus: <ul style="list-style-type: none"> <li>■ Autoclave available</li> </ul>
3	Indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure	BSL-2 practice plus: <ul style="list-style-type: none"> <li>■ Controlled access</li> <li>■ Decontamination of all waste</li> <li>■ Decontamination of laboratory clothing before laundering</li> </ul>	Primary barriers: <ul style="list-style-type: none"> <li>■ BSCs or other physical containment devices used for all open manipulations of agents</li> <li>■ PPE: Protective laboratory clothing, gloves, face, eye and respiratory protection, as needed</li> </ul>	BSL-2 plus: <ul style="list-style-type: none"> <li>■ Physical separation from access corridors</li> <li>■ Self-closing, double-door access</li> <li>■ Exhausted air not recirculated</li> <li>■ Negative airflow into laboratory</li> <li>■ Entry through airlock or anteroom</li> <li>■ Hand washing sink near laboratory exit</li> </ul>
4	<ul style="list-style-type: none"> <li>■ Dangerous/exotic agents which pose high individual risk of aerosol-transmitted laboratory infections that are frequently fatal, for which there are no vaccines or treatments</li> <li>■ Agents with a close or identical antigenic relationship to an agent requiring BSL-4 until data are available to redesignate the level</li> <li>■ Related agents with unknown risk of transmission</li> </ul>	BSL-3 practices plus: <ul style="list-style-type: none"> <li>■ Clothing change before entering</li> <li>■ Shower on exit</li> <li>■ All material decontaminated on exit from facility</li> </ul>	Primary barriers: <ul style="list-style-type: none"> <li>■ All procedures conducted in Class III BSCs or Class I or II BSCs in combination with full-body, air-supplied, positive pressure suit</li> </ul>	BSL-3 plus: <ul style="list-style-type: none"> <li>■ Separate building or isolated zone</li> <li>■ Dedicated supply and exhaust, vacuum, and decontamination systems</li> <li>■ Other requirements outlined in the text</li> </ul>

# ADDITIONAL CONTAINMENT CATEGORIES

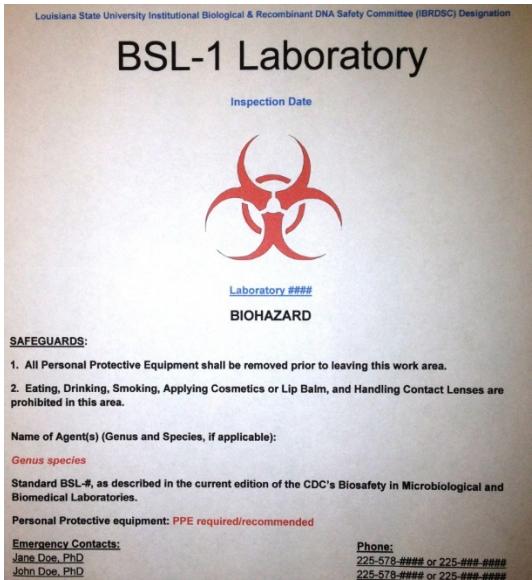
- ABSL-1, ABSL-2, ABSL-3, ABSL-4
  - Animal hosts
- BL1-P, BL2-P, BL3-P, BL4-P
  - Plant hosts and rDNA in plants
- BL1-N, BL2-N, BL3-N, BL4-N
  - rDNA in animals
- ACL-1, ACL-2, ACL-3, ACL-4
  - Arthropods

# UNIVERSITY INSPECTIONS

- Checklist of items that correspond to federal regulations and guidelines
  
- Assess for the presence of:
  - Biosafety Manual and SOPs
  - Proper Training of Lab Staff
  - Appropriate Posting/Labeling
  - Safety Materials (*i.e.*, 1<sup>st</sup> Aid Kit, eye wash, etc.)
  - Proper PPE
  - Laboratory Design and Setup
  - Proper Waste Disposal

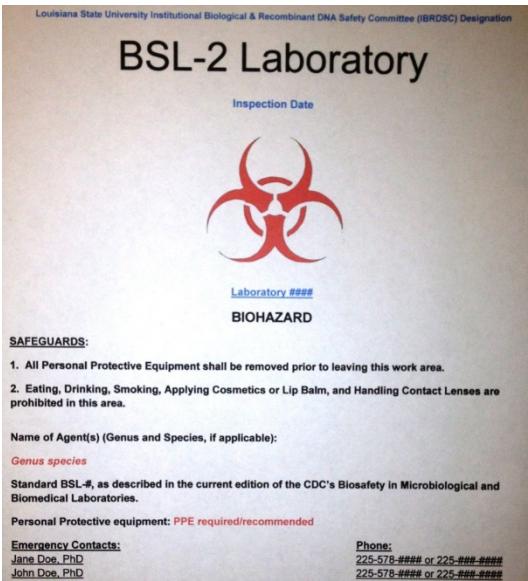


# DOOR POSTINGS



- ❖ **Example of biosafety sign posted outside of research labs listing:**

- **Lab's biosafety level**
- **Agents being studied**
- **Contact information for responsible persons including emergency contact numbers**



# SUMMARY

- ❖ Research should be evaluated from a biosafety as well as a biosecurity standpoint.
- ❖ Biosafety guidelines have been developed to protect workers in microbiological and medical labs through a combination of safeguards including engineering controls, management policies, and work practices.
- ❖ Differences between biosafety levels dictate necessary precautions required for each level.
- ❖ When in doubt, refer back to the Biosafety in Microbiological and Biomedical Laboratories book.