

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

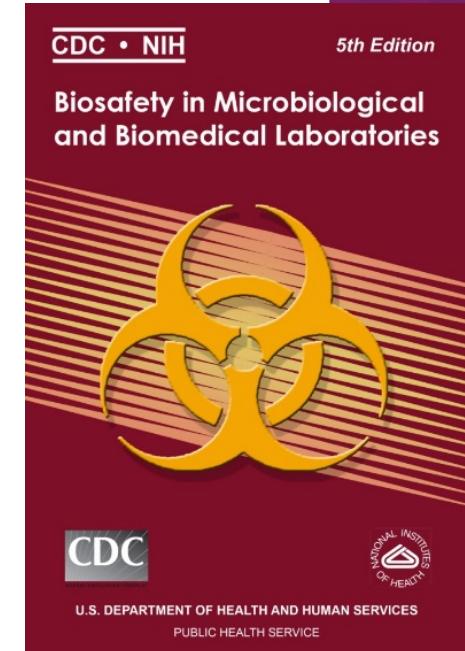
- ❖ Laboratorians recognize the hazards of processing infectious agents.
- ❖ Regulations outline precautions, special practices, and decontamination procedures.
- ❖ Guidelines have been developed to protect workers in microbiological and medical labs through engineering controls, management policies,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

http://oba.od.nih.gov/rdna/nih_guidelines_oba.html



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

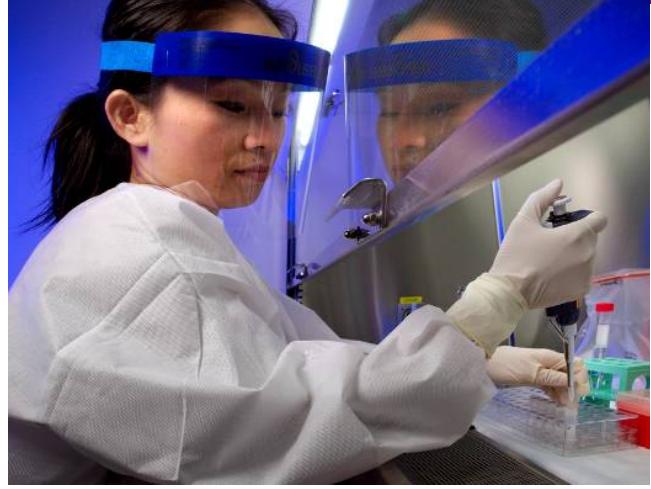
- Developed specifically for each laboratory
 - Identifies hazards
 - Specifies practices & procedures to minimize or eliminate these hazards
- Required reading
- Laboratory personnel
 - Responsible for work conducted in laboratory
 - Trained & knowledgeable in techniques, safety procedures, and associated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

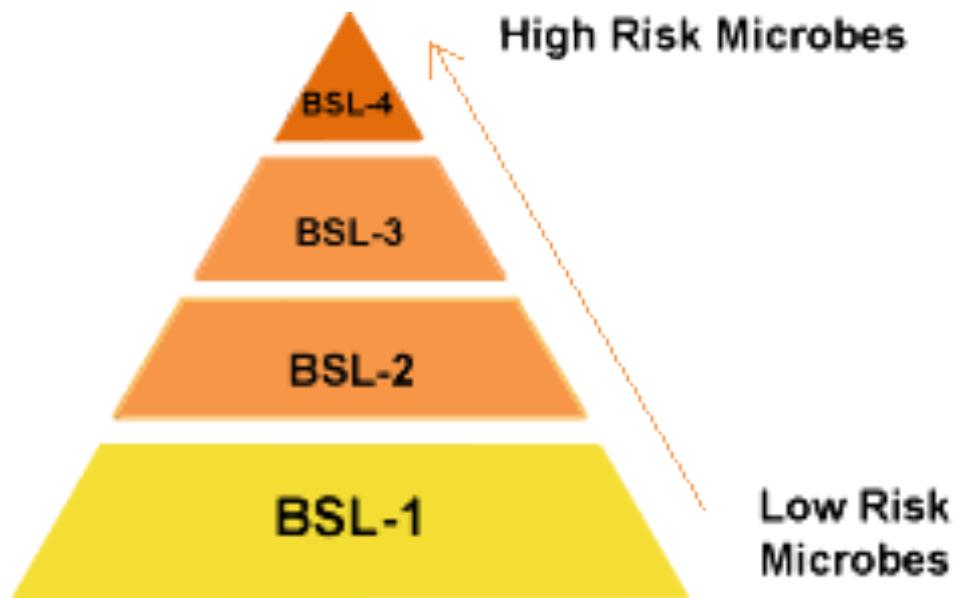
- Laboratory worker protection
- Protect persons outside lab
- Protects community/environment

- 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

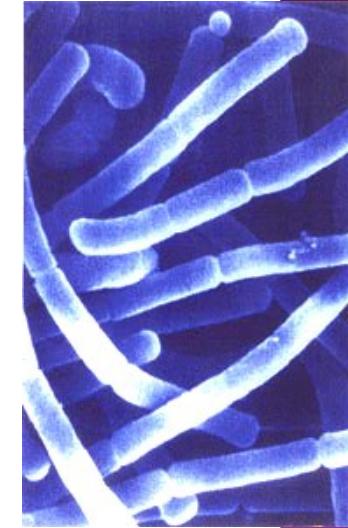
- Assignment of Biosafety Levels (BSL)
 - Lab practices and techniques
 - Safety equipment
 - Laboratory facilities
- Determined by risk assessment
- Established by responsible staff



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

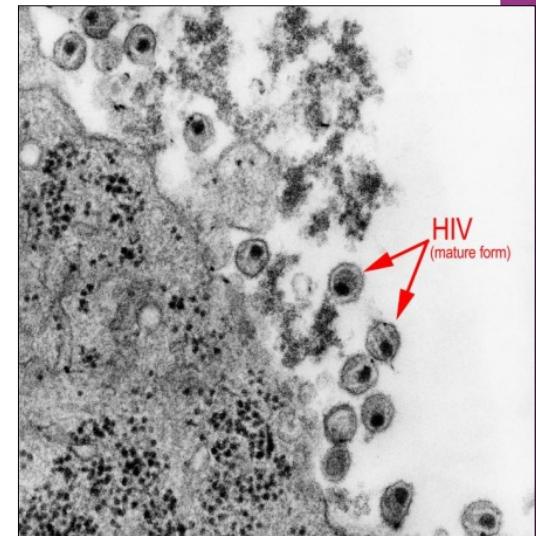
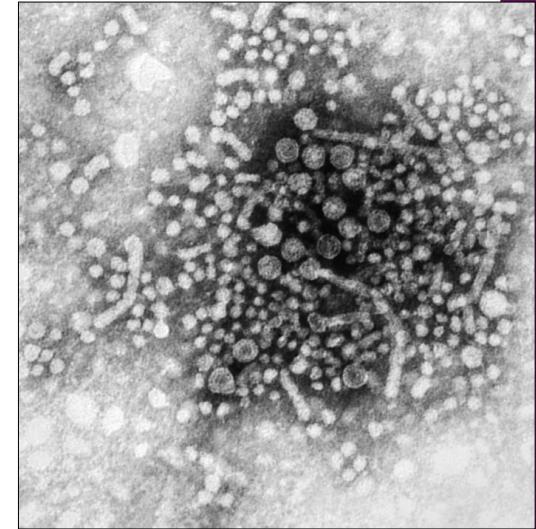
- Type of laboratory

- 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

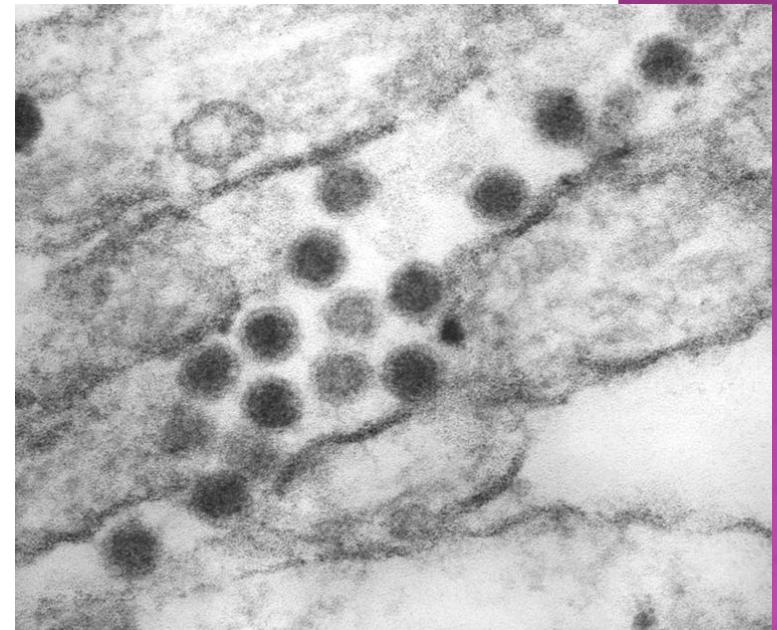
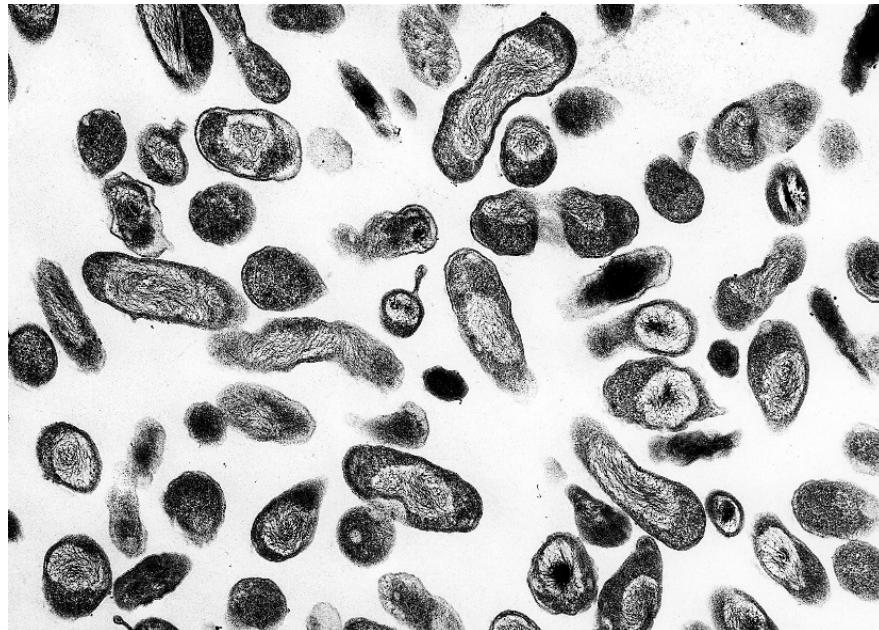
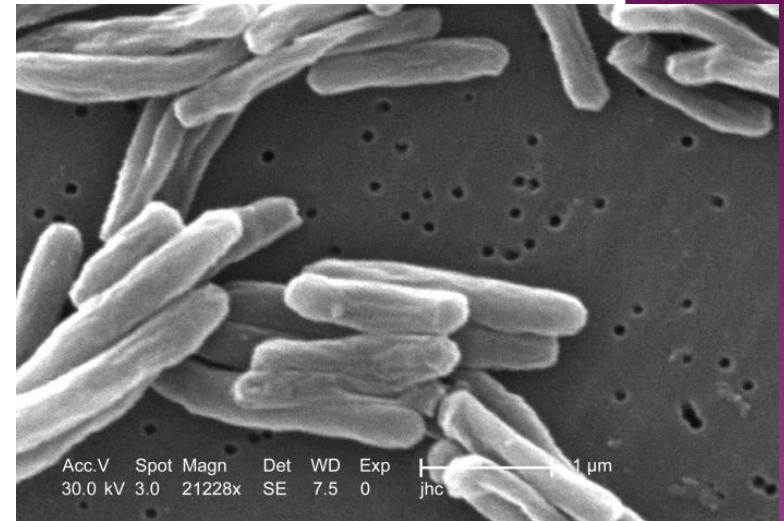
BSL-3

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

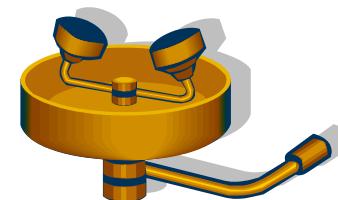
ADDITIONAL CONTAINMENT CATEGORIES

- 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

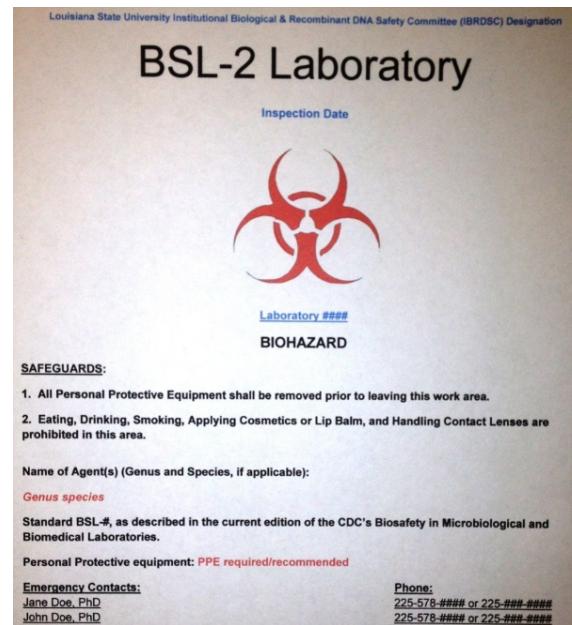
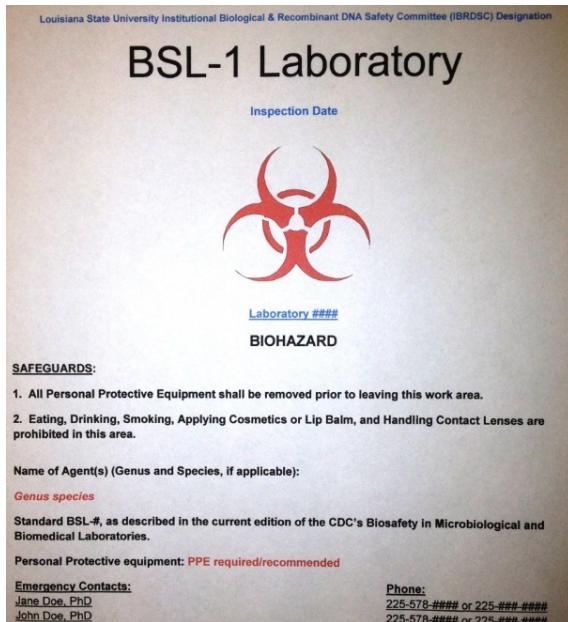
UNIVERSITY INSPECTIONS

- 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.*, 1st 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.