BIOHAZARDS

Biohazards refer to biological substances that pose a threat to the health of living organisms, primarily humans. Here are the main types of biohazards and their potential consequences:

1. Infectious Agents

- These are microorganisms that can cause disease in humans, animals, or plants.
- **Consequences**: Can lead to diseases ranging from mild (like the common cold) to severe (such as HIV/AIDS, tuberculosis, or COVID-19), llead to loss of life. **Examples**:
    - **Bacteria**: *Strepto coccus, Escherichia coli* (E. coli), *Mycobacterium tuberculosis*.
    - **Viruses**: *HIV* (causing AIDS), *SARS-CoV-2* (causing COVID-19), *Rhinovirus (Common cold)*
    - **Fungi**: *Aspergillus* (causing lung infections), *Candida albicans* (causing yeast infections).
    - **Parasites**: *Plasmodium* (causing malaria), *Toxoplasma gondii* (causing toxoplasmosis).

2. Biological Toxins

- These are toxic substances produced by microorganisms, plants, or animals that can harm living organisms.
- **Consequences**: Exposure can result in poisoning, neurological damage, or death. Toxins can contaminate food or water supplies, leading to widespread health issues.
- **Examples**:
    - **Botulinum toxin**: causes botulism.
    - **Ricin**: Found in castor beans; highly toxic if ingested or inhaled.
    - **Tetrodotoxin**: Found in pufferfish; causes paralysis and death

3. Allergens

- Substances that cause allergic reactions in some individuals.
- **Consequences**: Can trigger allergic reactions ranging from mild (sneezing, itching) to severe (anaphylaxis). Chronic exposure can lead to respiratory issues or other long-term health effects. Anaphylaxis is a **severe, life-threatening allergic reaction** that can occur rapidly after exposure to an allergen. It affects multiple systems in the body, often causing symptoms such as:

1. Difficulty breathing (due to swelling of the throat and airway)
2. Drop in blood pressure
3. Skin reactions like swelling
4. Nausea, vomiting, or diarrhea

5. Dizziness or fainting

- **Examples**:
    - **Pollen**: From trees, grasses, and flowers, leading to hay fever.
    - **Mold spores**: Can trigger asthma and other respiratory conditions.
    - **Pet dander**: Skin flakes from animals like cats and dogs, leading to allergies.

4. Genetically Modified Organisms (GMOs)

- Organisms whose genetic material has been altered using genetic engineering techniques.
- **Consequences**: While they can improve food security, concerns exist about potential impacts on human health, biodiversity, and ecosystems. Allergic reactions and resistance to antibiotics are potential risks.
- **Examples**:
    - **Bt Corn**: A GMO crop that produces a bacterial toxin harmful to pests but safe for humans.
    - **AquaBounty Salmon**: Genetically modified to grow faster than normal salmon.

5. Waste Products

- Biological waste from farming or industrial processes that can pose a biohazard.
- **Examples**:
    - **Manure**: Can carry harmful pathogens like *E. coli* and *Salmonella*.
    - **Animal remains**: Improper disposal can lead to the spread of diseases like anthrax.
- Medical Wastes: This includes any waste produced in healthcare settings that may be contaminated with infectious agents.
- **Examples**:
    - **Used syringes**: Can carry bloodborne diseases like *HIV* or *hepatitis C*.
    - **Surgical instruments**: If not sterilized, can lead to infection transmission.
    - **Bandages and dressings**: Contaminated with bodily fluids and infectious agents
- **Consequences**: Can harbor pathogens and lead to infections. Improper disposal can contaminate soil and water, posing risks to public health and the environment.

6. Vectors

- Animals that transmit diseases to humans.
- **Examples**:
    - **Mosquitoes**: Carry malaria, Zika virus, and dengue fever.
    - **Ticks**: Transmit Lyme disease and Rocky Mountain spotted fever.
    - **Rats**: Spread diseases like leptospirosis and hantavirus.

- **Consequences**: These organisms can transmit diseases (e.g., malaria, Lyme disease) to humans. Vector-borne diseases can lead to epidemics and have significant public health implications.

7. Human and Animal Bodily Fluids

- Blood, urine, saliva, and other body fluids that can carry infectious pathogens.
- **Examples**:
    - **Blood**: May carry bloodborne pathogens like *HIV* or *hepatitis B*.
    - **Saliva**: Can spread diseases.
    - **Semen**: Can transmit sexually transmitted infections (STIs) like gonorrhea.

8. Recombinant DNA Technology

- DNA molecules that are artificially combined from different organisms.
- **Examples**:
    - **Gene therapy viruses**: Modified viruses used in treatments but pose a risk of unintended consequences if mishandled.
    - **Laboratory pathogens**: Engineered bacteria or viruses for research purposes.

BSLs

Biosafety Levels (BSLs) are defined safety protocols designed to protect laboratory personnel, the environment, and the product when handling biological agents.

Each biosafety level BSL-1 to BSL-4 is defined based on the following:

1. Risks related to containment
2. Severity of infection
3. Transmissibility
4. Nature of the work conducted within the lab
5. Origin of the microbe
6. Agent in question
7. Route of exposure

1. Biosafety Level 1 (BSL-1)

- **Description**: The lowest level of biosafety, designed for labs working with agents that pose minimal threat to humans or the environment.
- **Examples of Agents**: Non-pathogenic *Escherichia coli* (E. coli).
- **Containment Practices**: Standard microbiological practices (hand washing, use of gloves).
- **Risk Level**: Minimal; agents used are unlikely to cause disease in healthy individuals.

2. Biosafety Level 2 (BSL-2)

- **Description**: Used for labs handling moderate-risk agents that can cause human disease but are usually not lethal, and have available treatments or vaccines.
- **Examples of Agents**: *Staphylococcus aureus*, *Salmonella*, *HIV*.
- **Containment Practices**: Access to the lab is restricted, and work is conducted in biological safety cabinets (BSCs)
- **Risk Level**: Moderate; agents may cause infection through accidental ingestion, inhalation, or contact with mucous membranes.

3. Biosafety Level 3 (BSL-3)

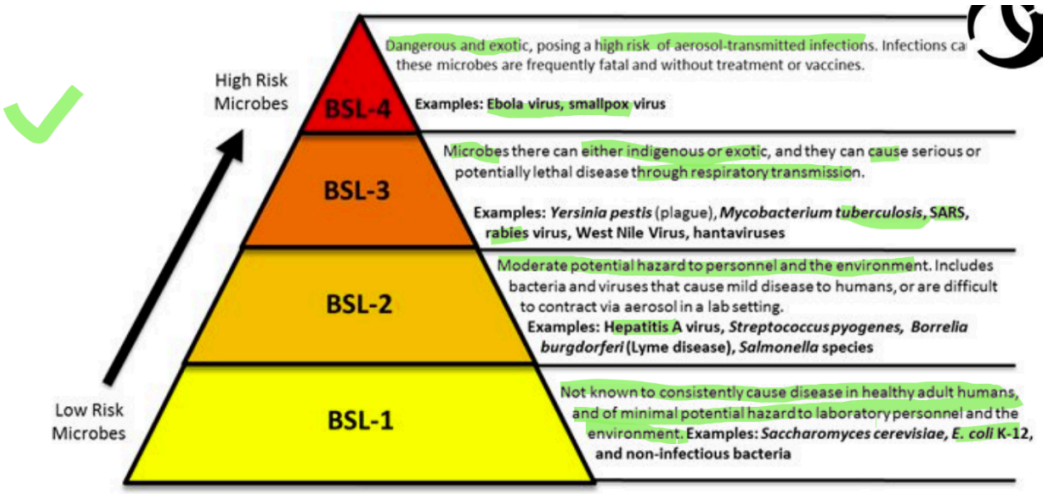
- **Description**: For labs working with agents that can cause serious or potentially lethal diseases, especially through inhalation, but for which there may be available treatments.
- **Examples of Agents**: *Mycobacterium tuberculosis* (causing tuberculosis), *SARS-CoV-2*, *Yersinia pestis* (causing plague).
- **Containment Practices**: All work is done in biological safety cabinets or other containment devices. The lab has controlled access, and personnel must be monitored and possibly vaccinated.
- **Risk Level**: High; these agents can cause severe disease if inhaled, though treatments or vaccines are often available.

4. Biosafety Level 4 (BSL-4)

- **Description**: The highest level of biosafety, reserved for labs handling dangerous and exotic agents that pose a high risk of aerosol-transmitted infections, have no known treatment or vaccine, and often result in fatal outcomes.
- **Examples of Agents**: Ebola virus, Marburg virus, Lassa fever virus.
- **Containment Practices**: Full isolation and the highest level of containment. All work is done in Class III biological safety cabinets or by personnel wearing full-body, air-supplied suits.
- **Risk Level**: Extreme; agents are life-threatening, and there is no available treatment or vaccine.

Summary Table:

BSL	Risk Level	Examples of Agents	Key Features
BSL-1	Minimal	*E. coli (non-pathogenic)*	Basic safety (lab coat, gloves), open bench work.
BSL-2	Moderate	*Staphylococcus aureus, HIV*	Restricted access, BSC for aerosols, lab waste decontamination.
BSL-3	High	*Mycobacterium tuberculosis, SARS-CoV-2*	Controlled airflow, respiratory protection, HEPA filters.
BSL-4	Extreme	*Ebola virus, Marburg virus*	Complete isolation, full-body suits, airlocks, specialized building design.



BIOSAFETY CABINETS

Biological Safety Cabinets (BSCs) are specialized ventilation devices used in laboratories to provide a clean and safe environment when handling biohazardous materials. They protect personnel, products, and the surrounding environment from exposure to harmful biological agents and cross-contamination during laboratory work. BSCs are an essential part of biosafety practices, especially in laboratories working with infectious or hazardous materials.

There are **three main classes of BSCs** Class I, Class II, and Class III each designed for specific containment needs, along with a **Class IV** environment for extreme containment.

Biosafety cabinets are only used for certain risk group organisms and for processes that might result in aerosol formation. These cabinets are provided with HEPA-filters that decontaminate the air moving out of the Cabinet.

BSCs are an essential part of biosafety as they minimize the formation of aerosol, protecting the environment, the pathogen, and the laboratory personnel. Besides, most BSCs also function to sterilize biological materials that are kept inside the cabinets.

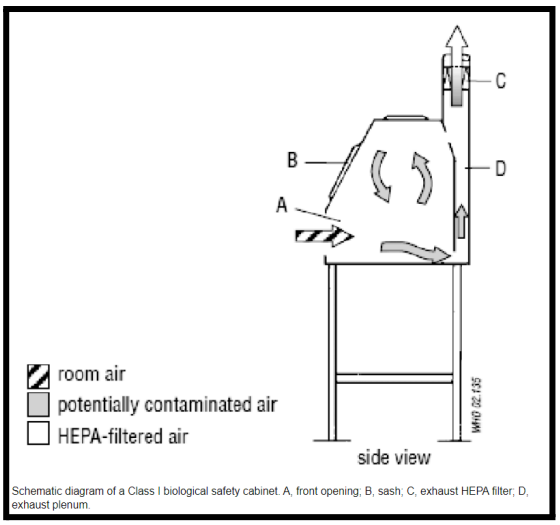
1. Class I Biological Safety Cabinet

- **Purpose**: Provides protection for laboratory personnel and the environment but does **not protect the product** from contamination.
- **Design**:

1. Room air is pulled into the cabinet through an opening, where the lab worker's arms can enter to handle the materials inside.

2. Any harmful particles that might be released during work, like from spinning liquids in a centrifuge or mixing cultures, are sucked inside the cabinet.
3. The air carrying these harmful particles is passed through a **HEPA filter** (a high-efficiency filter that captures almost all particles).
4. The air leaving the cabinet is clean and free of harmful particles, making sure the environment stays safe.
5. The cabinet can either be **ducted** (connected to the building's exhaust system to send air outside) or **unducted** (where the clean air is recycled back into the lab).

- **Use**: Suitable for work with low to moderate-risk agents (BSL-1, BSL-2).
- **Example Applications**: Handling pathogens like *Salmonella*, preparing chemical solutions that produce aerosols.



Schematic diagram of a Class I biological safety cabinet. A, front opening; B, sash; C, exhaust HEPA filter; D, exhaust plenum.

2. Class II Biological Safety Cabinet

- **Purpose**: Provides protection for personnel, the environment, and **the product** (sample). It is the most commonly used BSC in labs.
- **Design**:

1. A fan at the top of the cabinet creates a curtain of sterile air that flows over the workstation where biological materials are handled.
2. The air moves downwards, under the work surface, and then rises back to the top of the cabinet. This air passes through **HEPA filters**, which remove harmful particles.
3. Air is drawn in from the front of the cabinet, creating a barrier that protects the operator from potentially contaminated air.

- **Type A1**:

1. Minimum inflow speed: 75 ft/min.
2. Air is mixed and can be recirculated or exhausted.
3. Not recommended for hazardous chemicals.

- **Type A2**:

1. Minimum inflow speed: 100 ft/min.
2. 60-70% of air is recirculated, 30-40% is exhausted.
3. Must vent hazardous chemicals outside.

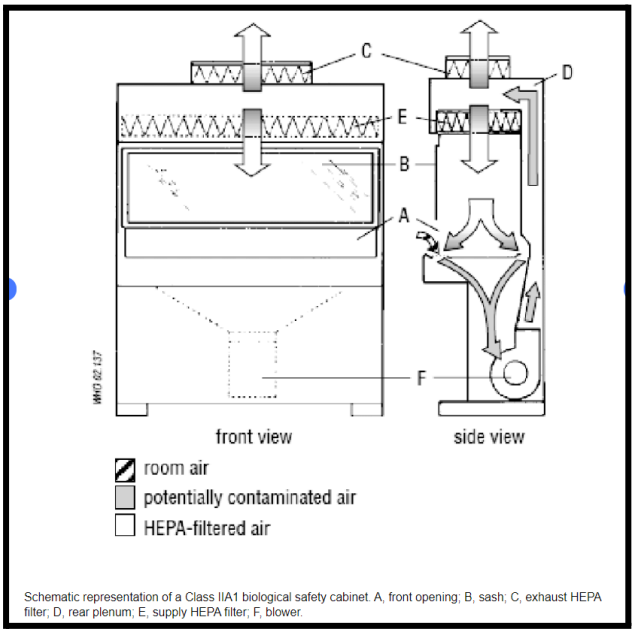
- **Type B1**:

1. Uses single-pass airflow to control hazardous vapors.
2. 40% air recirculated, 60% exhausted.
3. Includes a dedicated exhaust duct.

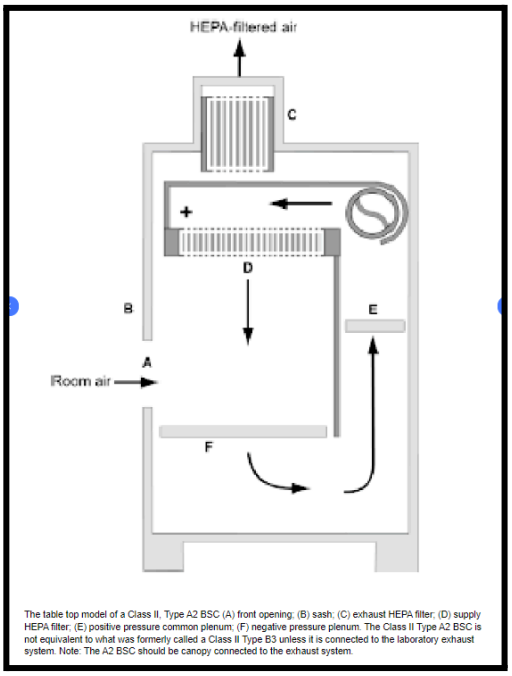
- **Type B2**:

1. 100% of the air is filtered and exhausted outside.
2. No air is recirculated within the cabinet.
3. Ideal for tasks with toxic vapors.

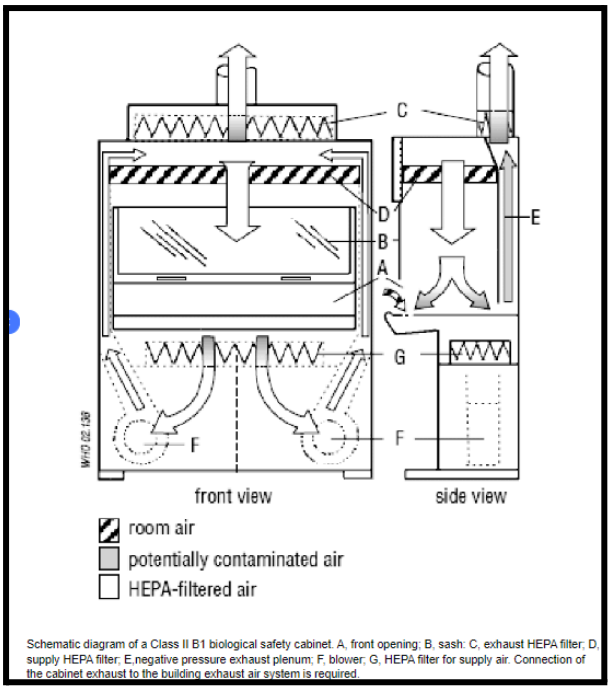
- **Use**: Suitable for handling moderate to high-risk agents (BSL-2, BSL-3), such as HIV, influenza, and other infectious pathogens.
- **Example Applications**: Cell culture work, handling potentially infectious samples, pharmaceutical research.



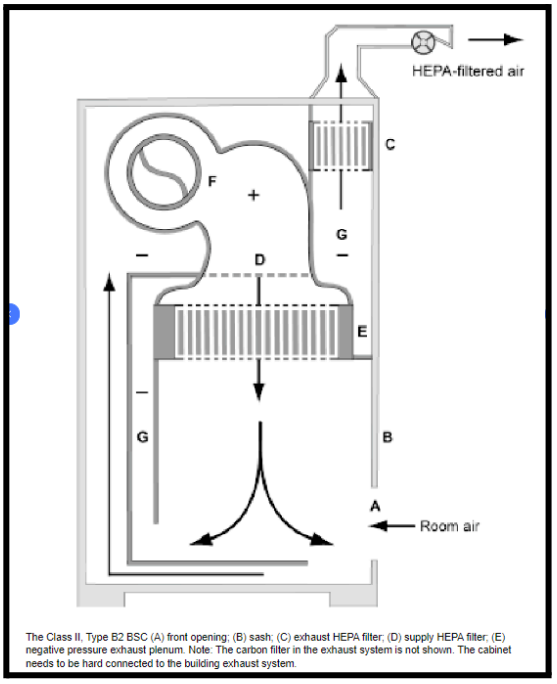
Schematic representation of a Class IIA1 biological safety cabinet. A, front opening; B, sash; C, exhaust HEPA filter; D, rear plenum; E, supply HEPA filter; F, blower.



The table top model of a Class II, Type A2 BSC (A) front opening; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) positive pressure common plenum; (F) negative pressure plenum. The Class II Type A2 BSC is not equivalent to what was formerly called a Class II Type B3 unless it is connected to the laboratory exhaust system. Note: The A2 BSC should be canopy connected to the exhaust system.



Schematic diagram of a Class II B1 biological safety cabinet. A, front opening; B, sash: C, exhaust HEPA filter; D, supply HEPA filter; E,negative pressure exhaust plenum; F, blower; G, HEPA filter for supply air. Connection of the cabinet exhaust to the building exhaust air system is required.



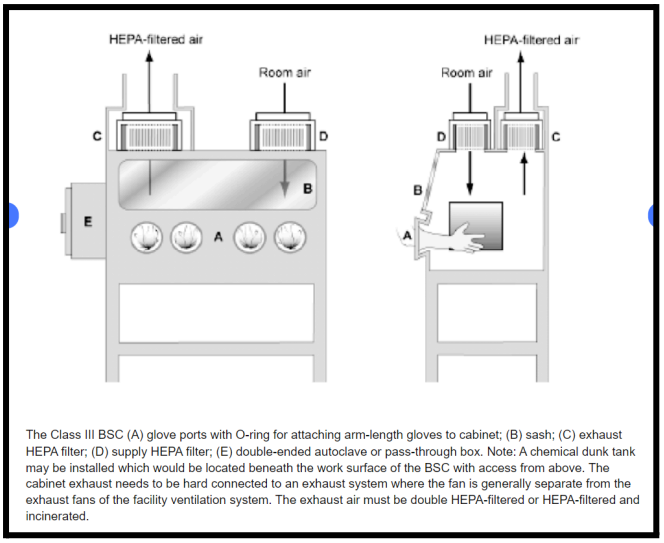
The Class II, Type B2 BSC (A) front opening; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) negative pressure exhaust plenum. Note: The carbon filter in the exhaust system is not shown. The cabinet needs to be hard connected to the building exhaust system.

3. Class III Biological Safety Cabinet

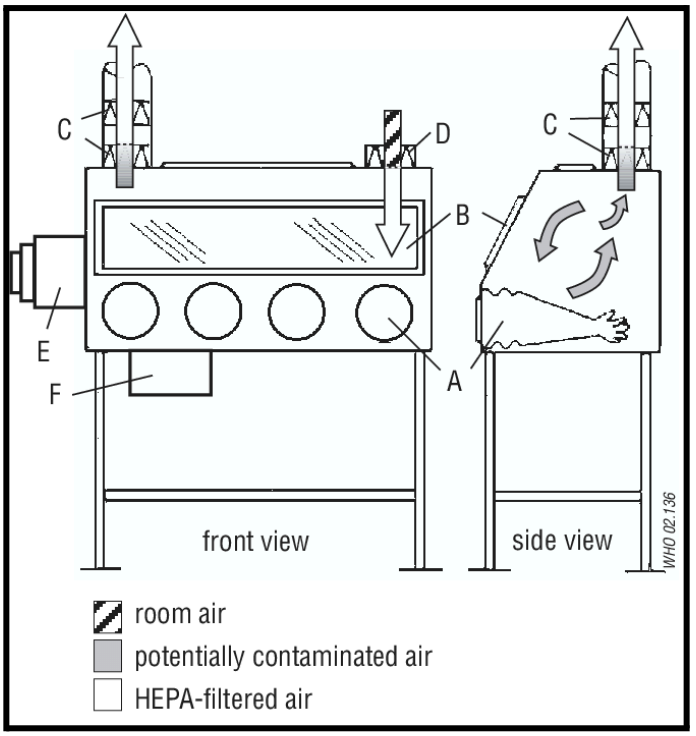
- **Purpose**: Provides the highest level of protection for **personnel, product, and the environment**. It is used for highly dangerous pathogens that pose a significant risk of aerosol transmission and often lack vaccines or treatments.
- **Design**:

1. Rubber Gloves are attached to the cabinet, allowing operators to handle materials without direct contact, hence the name "glove boxes."
2. Transfer Chamber allows for the sterilization of materials before they exit the cabinet, reducing contamination risks.
3. While the gloves restrict movement, they effectively prevent contact with hazardous samples, enhancing safety.
4. The exhaust air is filtered through **double HEPA filters** or treated with **incineration**, ensuring that harmful particles do not escape into the environment.
5. These cabinets are often designed to fit specific laboratory requirements, incorporating necessary equipment within the chamber.

- **Use**: Used for work with extremely hazardous materials (BSL-3, BSL-4), such as Ebola, Marburg virus, or highly contagious pathogens.
- **Example Applications**: Handling dangerous and exotic pathogens that require high containment.



The Class III BSC (A) glove ports with O-ring for attaching arm-length gloves to cabinet; (B) sash; (C) exhaust HEPA filter; (D) supply HEPA filter; (E) double-ended autoclave or pass-through box. Note: A chemical dunk tank may be installed which would be located beneath the work surface of the BSC with access from above. The cabinet exhaust needs to be hard connected to an exhaust system where the fan is generally separate from the exhaust fans of the facility ventilation system. The exhaust air must be double HEPA-filtered or HEPA-filtered and incinerated.



4. Class IV Environments (Biosafety Level 4 Facilities)

- **Purpose**: Provides **extreme containment** for the most dangerous pathogens in a controlled laboratory environment.
- **Design**:
  - These are not standalone cabinets but entire labs designed to handle BSL-4 pathogens. Workers wear **full-body, air-supplied suits** and enter/exit through airlocks. All materials leaving the lab must be decontaminated.
  - Laboratories are sealed, with specialized air and waste decontamination systems.
- **Use**: Only for work with the highest risk agents (BSL-4) that pose a severe risk to humans and for which there are no treatments or vaccines (e.g., Ebola, Lassa virus).
- **Example Applications**: Research on deadly viruses or testing vaccines for pathogens with high lethality.

Key Points of Comparison:

Class	Personnel Protection	Product Protection	Environmental Protection	Typical Use
Class I	Yes	No	Yes	Basic research, low/moderate risk pathogens (BSL-1, BSL-2)
Class II	Yes	Yes	Yes	Cell culture, viral research, moderate risk agents (BSL-2, BSL-3)
Class III	Yes (Highest)	Yes	Yes	Highly dangerous agents (BSL-3, BSL-4)
Class IV (Lab Environment)	Full-body suit protection	Yes	Yes	Extreme containment, BSL-4 labs (Ebola, Marburg)

Biosafety Level	BSL-1	BSL-2	BSL-3	BSL-4
Description	· No Containment · Defined organisms · Unlikely to cause disease	· Containment · Moderate Risk · Disease of varying severity	· High Containment · Aerosol Transmission · Serious/Potentially lethal disease	· Max Containment · "Exotic," High-Risk Agents · Life-threatening disease
Sample Organisms	E.Coli	Influenza, HIV, Lyme Disease	Tuberculosis	Ebola Virus
Pathogen Type	Agents that present minimal potential hazard to personnel & the environment.	Agents associated with human disease & pose moderate hazards to personnel & the environment.	Indigenous or exotic agents, agents that present a potential for aerosol transmission, & agents causing serious or potentially lethal disease.	Dangerous & exotic agents that pose a high risk of aerosol-transmitted laboratory infections & life-threatening disease.
Autoclave Requirements	None	None	Pass-thru autoclave with Bioseal required in laboratory room.	Pass-thru autoclave with Bioseal required in laboratory room.