

BIOSAFETY AND BIOSECURITY HANDBOOK FOR STUDENTS IN NIGERIA

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PREFACE

Biosecurity is an emerging discipline with the purpose of preventing theft, loss, misuse, and intentional release of valuable biological materials (VBM). It is a topic that requires increased awareness especially with the rapid development in Science and Technology, and how its definition globally has extended to address threats to the economy, the environment, agriculture, and human health.

While various Organisations and agencies are mainly focused on providing biosecurity awareness amongst the young adults (20-40) the much younger population seem to be neglected (18 and below), who due to improved science literacy partake in Science, Technology, Engineering, and Mathematics (STEM) education at secondary school level including exposure to aspects of hands-on research and principles.

Children have the right to be informed in a simplified medium they can understand (Art. 13, UNCRC; Article 11 of the Charter) so they can have views on matters affecting them (Article 12, UNCRC; Article 24.1 of the Charter).

Therefore, the need to provide basic biosecurity and biosafety education is not only recommended but timely to inculcate a culture of safety, security, and responsibility within the next generation of scientists. There is an increase in scientific experimentation in Secondary schools in Nigeria. Hence, the need for students to be aware of best biosafety practices and the risks associated with working in the laboratory.

As part of a strategy to bridge this gap, create awareness and promote inclusion of biosecurity and biosafety education in schools, we, the Youth for Biosecurity 2021 and 2022 Cohort- Nigeria Participants came together to produce this Biosafety and Biosecurity handbook.

We want to especially extend our gratitude to the United Nations Office of Disarmament Affairs (UNODA) and the Biological Weapon Convention Implementation Support Unit (BWC ISU) for organizing the workshop with the support of the European Union (EU), and for showing us that we can create an impact at the National level.

-Youth for Biosecurity 2021 and 2022 Cohort Nigerian Participants

PURPOSE OF THIS HANDBOOK



The main target of this handbook is secondary school pupils that are beginning to explore, understand and conduct projects in science related subjects that may include working with potential VBM's. The handbook aims to:

- Introduce the concept of Biosecurity and Biosafety to the students.
- To provide guidelines, good practices, and ethics in science
- And to engender a culture of responsibility in handling biological materials in their school laboratories.

TABLE OF CONTENTS

| | |
|---|----|
| Preface | I |
| Purpose of this Handbook | II |
| Introduction to Biosafety and Biosecurity | 01 |
| What is Biosafety? | 01 |
| Objectives Of Biosafety | 01 |
| Components of Biosafety | 01 |
| 1. Laboratory Practice and Technique | 01 |
| 2. Personal Protective Equipment (PPE) | 02 |
| Safety Equipment | 02 |
| Facility Design | 02 |
| Biosafety Levels (BSL) | 03 |
| What is Biosecurity? | 04 |
| Objectives of Biosecurity | 04 |
| Types of Biosecurity | 04 |
| 1. Laboratory Biosecurity | 04 |
| 2. Farm Biosecurity | 05 |



Relationship between laboratory Biosecurity and Biosafety — 06

Biological Risk — 07

Biological Weapons Convention (BWC) — 09

Key Provisions of the Convention — 09

One Health Approach as a Solution to Biosecurity — 10

Why is One Health Important? — 12

How does One Health Work? — 13

Four Pillars of One Biosecurity — 13

Disciplines Associated with Biosafety and Biosecurity — 14

Where can Biosafety and Biosecurity Experts work? — 15

Existing Associations on Biosafety and Biosecurity — 15

International Regulatory Framework and Guidance
Documents on Safe Handling of Biological Materials — 15

Safety Mantra — 16

How Do You Use Laboratory Personal Protective Equipment — 17

Glossary — 19

Abbreviations — 20

References — 20



INTRODUCTION TO BIOSAFETY AND BIOSECURITY

What is Biosafety?

Biosafety is the safe working practice that addresses containment principles, technologies and practices that are implemented to prevent the **unintentional** exposure to biological materials or their accidental release. It is the term used to refer to all possible methods employed to stop accidental contact with biological agents.

“KEEPING BAD BUGS AWAY FROM PEOPLE”

(US National Research Council (2009))

Objectives of Biosafety

To protect everyone and the environment from accidental release of biological materials.

Components of Biosafety

Essential components of biosafety guidelines contain some or all the following:

1. Laboratory Practice and Technique: Individuals working with biological agents must be aware of hazards and be trained to safely handle and dispose of these materials. Laboratories must have written Standard Operating Procedures (SOPs).

Some basic safety rules for school laboratories include:

- Always read the standard operating procedure (SOP) before carrying out an experiment. **Cautions** described in the laboratory exercises.
- Use Laboratory coats, gloves, and safety eye wears.
- Know what you are doing by reading the assigned experiment before you start to work in the laboratory.
- Wash and sanitize your hands after all Laboratory activities, following the removal of gloves and immediately following contact with infectious agents.
- Decontaminate work surfaces before and after use and immediately after spills.

- Microbial waste should be decontaminated and disposed of properly.
- Pay close attention to any tears and other personal protective equipment.
- Assume that accidents will occur and plan for safely managing those events when handling biohazardous materials and agents.
- Report all accidents or incidents to your supervisor immediately.
- Unauthorized experiments or procedures **must not** be attempted.
- Leave your workstation clean and in good order before leaving the laboratory.
- Use disinfectants or sterilants with proven efficacy against the specific biohazardous agent(s) you are using.
- No eating, drinking, or smoking in the laboratory at any time!

2. Personal Protective Equipment (PPE) is a specialized clothing or equipment worn by a person to provide protection against any hazard (e.g., infectious agents and toxins). Some examples of PPE include

- Laboratory coats
- Gloves
- Boots
- Face shield
- Masks
- Supplied-air respirators
- Safety eyewear (Goggles and Safety glasses)
- Ear plugs etc.

3. Safety Equipment includes Biological Safety Cabinets (BSCs), Laminar flow hoods, Safety centrifuge cups, enclosed containers and other engineered controls designed to minimize exposure to biological agents.

4. Facility Design: The design of a facility is important in providing a barrier to protect people working inside and outside the laboratory, as well as to protect the community from infectious agents that may be accidentally released from the laboratory including physical separation of laboratories from public access, specially designed ventilation systems (to prevent airborne biological agents from migrating outside the laboratory), and presence of autoclaves (to sterilize biohazardous waste before disposal).

BIOSAFETY LEVELS (BSL)

Depending on the biological agent handled in a laboratory we have four (4) biosafety levels.

- BSL-1 Laboratory: Agents not known to cause disease and present a minimal hazard to laboratory personnel and the environment.
- BSL-2 Laboratory: Builds on BSL-1. Biological Agents pose moderate hazards to laboratory personnel and the environment. Usually indigenous and associated with diseases of varying severity.
- BSL-3 Laboratory: Builds on BSL-2. Biological agents can be indigenous or exotic and can cause potentially deadly diseases by inhalation.
- BSL-4 Laboratory: Builds on containment requirements of BSL-3 and it's the highest level of biosafety.



WHAT IS BIOSECURITY?

Biosecurity describes the principles, technologies and practices that are implemented for the protection, control, and accountability for valuable biological materials to prevent their loss, theft, misuse, diversion, unauthorized access, or intentional release. It includes measures put in place to protect biological agents and their related equipment, information, and skills from getting into the wrong hands.

"KEEPING BAD PEOPLE AWAY FROM BUGS"

(US National Research Council (2009))

Objectives of Biosecurity

Protect biological materials from deliberate release into the environment.

Types of Biosecurity

Biosecurity is of various types as it applies to different fields. They include

1. Laboratory Biosecurity
2. Farm Biosecurity

1. Laboratory Biosecurity

This can be defined as safeguarding, controlling, and taking responsibility of high-risk biological agents, toxins, and valuable biological materials and information in the laboratory to prevent unauthorized possessions, loss, theft, misuse, diversion for malicious intent.

Components of Laboratory Biosecurity

- i. **Physical Security:** The main aim of this component is to create an access control in the laboratory by preventing unauthorized entry. This includes setting up cameras, and restricting movement in and out of the laboratories.
- ii. **Personnel Reliability:** This component focuses on ensuring that those working in the laboratory are responsible and can work with sensitive materials.
- iii. **Material Control:** Having proper control and inventory of materials that go in and out of the laboratory.
- iv. **Information Security:** This component focuses on putting in confidentiality measures to protect sensitive data.
- iv. **Transport Security:** Proper packaging of materials and follow up of materials to be transported out of the laboratory.

2. Farm Biosecurity

Farm Biosecurity is the prevention of disease-causing agents entering or leaving any place where they can pose a risk to farm animals, other animals, humans, or the safety and quality of a food product.

There are three (3) levels of Farm Biosecurity:

i. Conceptual Biosecurity

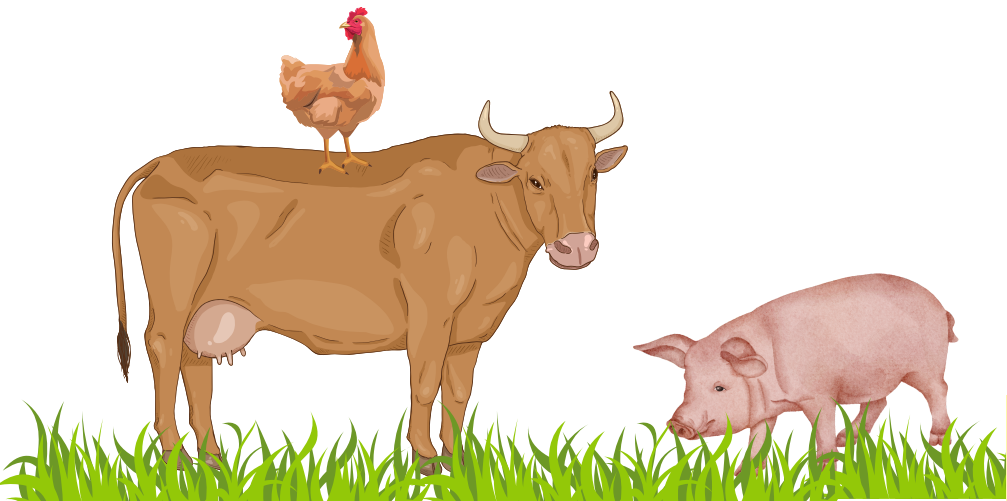
This is the primary level of biosecurity, and revolves around the location of animal facilities and their various components. The most effective way to limit risk is physical isolation, making this a primary consideration when citing new confinement facilities or farms.

ii. Structural biosecurity

This the secondary level of biosecurity deals with physical factors, such as farm layout, perimeter fencing, drainage, number/location of changing rooms, presence of showers, air filtration systems, enclosed loadouts, and housing design in general.

iii. Procedural biosecurity

This is the tertiary level of biosecurity, deals with routine procedures to prevent introduction (bioexclusion) and spread (biocontainment) of infection within a facility. Such processes and activities should be constantly reviewed as part of a disease control programs and quickly adjusted in response to disease emergencies.



RELATIONSHIP BETWEEN LABORATORY BIOSECURITY AND BIOSAFETY

Biosafety and Biosecurity programs both aim to minimize the risk of exposure of individuals and the environment to potentially hazardous biological agents, while the former focuses on accidental release the later addresses laboratory risks and threats beyond unintentional exposure.

In the figure below, we see how Biosecurity practices build on and share many components with Biosafety.

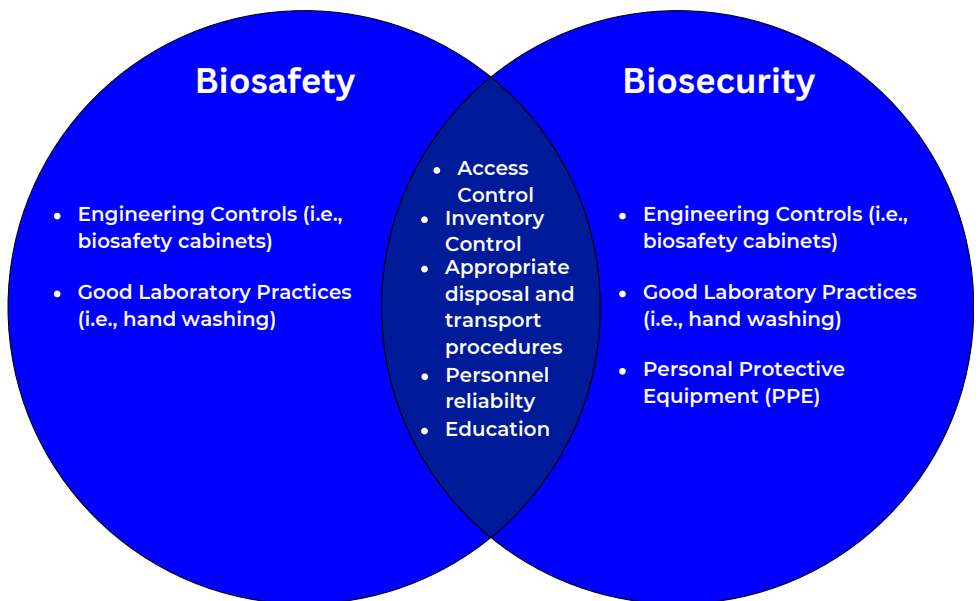


Figure 1: Biosafety and Biosecurity Overlap

BIOLOGICAL RISK

What is Risk?

Risk is the combination of the likelihood of a hazard to cause harm and the severity of harm from contact with that hazard. Hazard means an object or situation that has the possibility to cause bad consequences upon exposure.

Before conducting an experiment, members of the team should do the following:

- Identify objects and steps in the process (hazard) that can result in harm
- Look into the identified hazards and bring out the risk associated with each.
- Determine appropriate ways to remove the hazards or how to reduce them if they cannot be eliminated using control measures such as PPE's and good practices.
- Implement the control measures.
- If something new is introduced to the procedure, re-examine the above points.
- Record and share with all involved with the experiment to ensure everyone is aware of the risks and hazards.
- All the above activities are what is referred to as **Risk Assessment**.

To conduct risk assessment, consideration is always given to the 5Ps (Pathogen, Personnel, Place, PPE and Procedures).

In biosecurity, there are risks that may arise from “dual use of life sciences”. These are lawful research but have the potential to be used for malicious purposes beyond their intended applications.

A wide range of potential risks and threats comes under the scope of biosecurity, from specific acts of violence to bioterrorism.

Biological risks could be:

- **Natural:** e.g., Pandemics (Covid-19) and epidemics.

Epidemics refers to an unexpected and sudden increase of illness within a region e.g smallpox and polio. While Pandemics is an epidemic that has spread across international boundaries and affects a lot number of people e.g COVID- 19).

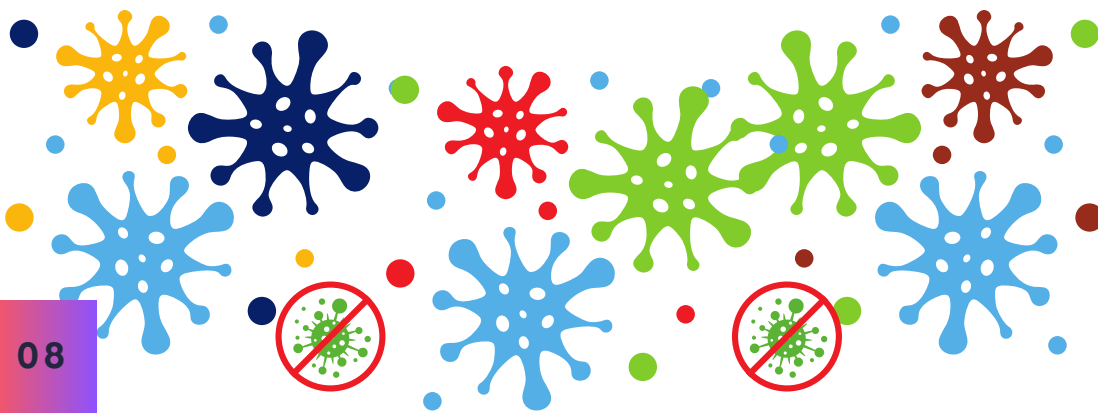
- **Accidental:** e.g., Laboratory acquired infections (LAIs).

Laboratory-acquired infections (LAIs) refers to all infection gotten through the laboratory and its activities.

- **Intentional:** e.g., Bioterrorism

Bioterrorism refers to the intentional release or threat of biological agents (i.e., viruses, bacteria, fungi, or their toxins) in order to cause disease or death among the human population or food crops and animals in order to cause harm to the public. Whereas the intentional release that affects agriculture and the food system specifically is known as Agroterrorism.

Agents used in bioterrorism are referred to as biological weapons, and they are capable of spreading highly contagious and lethal disease-causing organisms and toxins, resulting in dire consequences that led to not just loss of lives but food shortages, economic losses and more. It is due that the first treaty that bans this entire category of weapons of mass destruction (WMD) was constituted to bring countries together to sign an agreement known as The Biological Weapon Convention (BWC), and it so far has 184 countries as members.



BIOLOGICAL WEAPONS CONVENTION (BWC)

The Biological Weapons Convention (BWC), or Biological and Toxin Weapons Convention (BTWC). It is a disarmament treaty that effectively bans biological and toxin weapons by prohibiting their development, production, acquisition, transfer, stockpiling and use. Formerly known as the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction.

Key Provisions of the Convention

- **Article I:** Never under any circumstances to develop, produce, stockpile, acquire, or retain biological weapons.
- **Article II:** To destroy or divert peaceful purposes biological weapons and associated resources prior to joining.
- **Article III:** Not to transfer, or in any way assist, encourage, or induce anyone else to acquire or retain biological weapons.
- **Article IV:** To take any national measures necessary to implement the provisions of the BWC domestically.
- **Article V:** Undertaking to consult bilaterally and multilaterally and cooperate in solving any problems which may arise in relation to the objective, or in the application, of the BWC.
- **Article VI:** Right to request the United Nations Security Council to investigate alleged breaches of the BWC and undertaking to cooperate in carrying out any investigation initiated by the Security Council.
- **Article VII:** To assist States which have been exposed to danger as a result of a violation of the BWC.
- **Article X:** Undertaking to facilitate and have the right to participate in the fullest possible exchange of equipment, materials and information for peaceful purposes.

ONE HEALTH APPROACH: AS A SOLUTION TO BIOSECURITY

One Health is a concept that describes the relationship between animal, human, and the environment with regards to health and disease. The Food and Agriculture Organization of the United Nations (FAO) describes One Health as a holistic vision to address complex challenges that threaten human, and animal health, food security, poverty, and the environments where diseases flourish.

In addition, One Health is an approach to tackle complex public health problems that involve multiple disciplines, for example: emerging zoonotic diseases, food safety and selection of antimicrobial resistant pathogens.

The increasing interdependence of people with animals and their products has brought One Health to the forefront. Fundamental to the One Health concept is the importance of coordinated multidisciplinary collaboration working locally, nationally, and internationally, to attain optimal health for people, animals and our environment.

Biosecurity has been defined as a work of strategy, efforts and planning to protect human, animal and environmental health against pathogens. Biosecurity is based on the implementation of measures to prevent the introduction of disease into a population.

The three pillars of Biosecurity (human, animal, and environment) are shared by the One Health concept, and this forms the relationship.



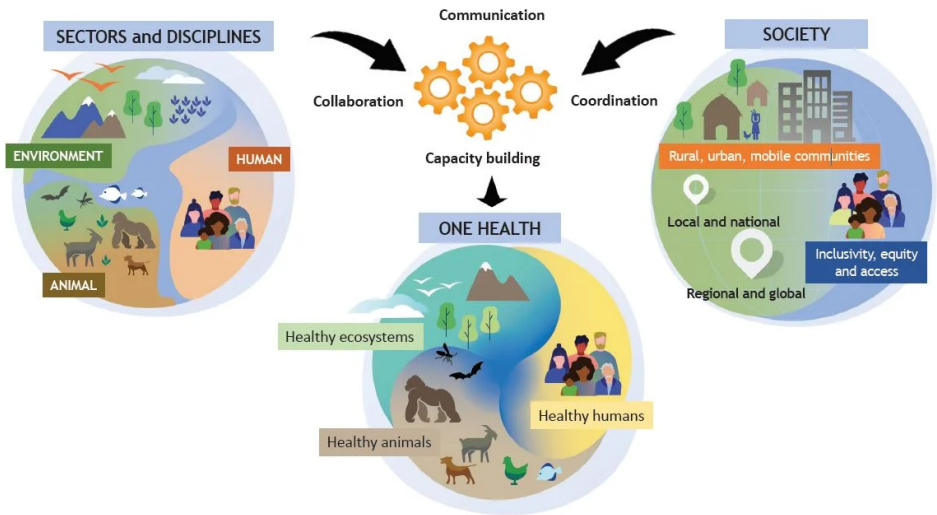


Figure 2: Illustration of the One Health approach by the OHHLEP

The One Health High Level Expert Panel (OHHLE) – the advisory panel convened by World Health Organization (WHO), Food and Agriculture Organization (FAO), World Organization for Animal Health (OIE) and United Nations Environment Programme (UNEP).

WHY IS ONE HEALTH IMPORTANT?

One Health is not new, but it has become more important in recent years because:

- i. The increase in the population of humans, as a result, more people live in close contact with wild and domestic animals, both livestock and pets. Close contact with animals has provided a medium for diseases to pass between animals and people. One health approach as a solution to Biosecurity
- ii. The earth has experienced changes in climate and land-use such as deforestation, desertification, drought, intensive farming practices, and wildlife hunting. These disruptions in environmental conditions have increased the transmission of diseases to animals.
- iii. There is a continuous movement (migration) of people, animals, and animal products across the globe. As a result, diseases can spread quickly across borders and regions of the world.
- iv. All these changes have significantly led to the emergence and re-emergence of zoonotic diseases (i.e. diseases that can spread between animals and people) such as COVID-19, Ebola, Lassa fever, Rabies, Brucellosis etc
- v. The concept of One Health includes zoonotic diseases, antimicrobial resistance (AMR), food safety, food security, vector-borne diseases, environmental contamination, and other health threats by people, animals, and the environment.



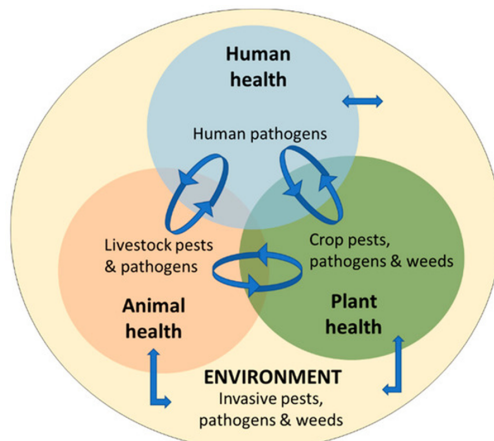
HOW DOES ONE HEALTH WORK?

- i. Bringing together many professionals with a range of expertise who are active in different sectors such as medical doctors, Environmentalist, Veterinary doctors, Plant Scientists, Researchers as well as Policymakers; to work closely.
- ii. Promotion of early detection, response, and prevention of outbreaks of zoonotic diseases such as Ebola, covid-19, Lassa fever etc. as well as food insecurity.
- iii. Addresses future challenges for human health, plant health, animal health and environment.
- iv. Improves coordination, collaboration, and communication at the human-animal-environment interface to address shared health threats such as zoonotic diseases, antimicrobial resistance, food safety and others.

The interconnectedness of One Health and Biosecurity forms One Biosecurity.

ONE BIOSECURITY

- (a) Human Biosecurity addresses zoonotic and emerging disease diagnosis and investigation.
- (b) Animal Biosecurity deals with disease prevention and control in livestock production holdings, aquaculture farms, and feed storage facilities.
- (c) Plant Biosecurity aims to safeguard plant industries and crop production.
- (d) Environmental Biosecurity is concerned with the protection of the environment and social amenities from the negative effects associated with invasive alien species.



Schematic representation of the links among human, animal, plant, and environmental health (Adapted from Hulme, 2020)

DISCIPLINES ASSOCIATED WITH BIOSAFETY AND BIOSECURITY

There are many disciplines associated with the field of Biosafety and Biosecurity. The activities happening in these two fields are being done by humans who have built a career for themselves in this field. These people are known as Biosafety and Biosecurity experts, and they have come together to form numerous associations and organizations globally.

Biosafety and Biosecurity focus on creating a safe place for humans, animals, plants, and the environment. It's obvious that one discipline cannot make this happen; different sectors will have to come together to achieve this.

The career opportunities in both fields include:

- Bio-risk Manager
- Biosafety Manager
- Plant Scientist
- Virologist
- Medical Microbiologist
- Laboratory Technologist
- Epidemiologist
- Environmentalist
- Ecologist
- Veterinary doctor
- Molecular scientist
- Genomic scientist
- Biomedical Scientist
- Biotechnologist
- Biochemist
- Bioinformatic expert
- Geneticist and the list goes on

Government Secondary School Gwarimpa Estate



Where can Biosafety and Biosecurity Experts work?

- Government organizations like Nigeria Centre for Disease Control (NCDC), State & Federal Ministries, Government Laboratories etc.
- Research Organizations- Private owned and Government-owned
- Laboratories
- Educational Institutes
- Hospitals and Health Facilities
- Think-tanks

Existing Associations on Biosafety and Biosecurity

- Nigerian Biological Safety Association (NiBSA)- Nigeria
- International Federation of Biosafety Associations (IFBA)- Canada
- The Association of Biosafety and Biosecurity- USA
- American Biological Safety Association (ABSA)- USA
- European Biosafety Association (EBSA)- Belgium
- African Biological Safety Association (AfBSA)-Kenya

International Regulatory Framework and Guidance Documents on Safe Handling of Biological Materials

1. WHO Laboratory Biosafety Manual 4th Edition.
2. ISO 35001: Biorisk management for laboratories and other related organizations.
3. Cartagena Protocol on Biosafety – requirements for transboundary movement of living modified organisms (LMOs).
4. Nagoya Protocol – biological and physical traceability requirements.
5. NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (2019).

SAFETY MANTRA

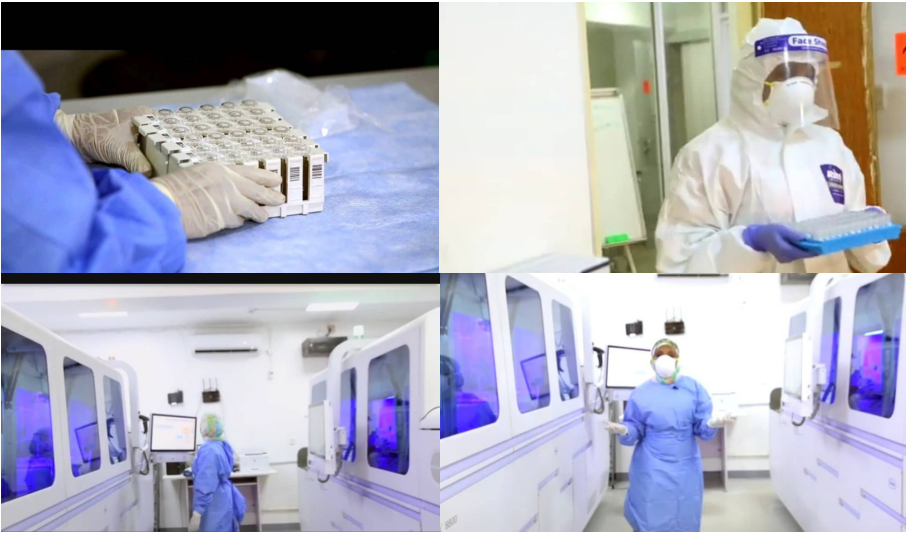
- Abide by guidelines regarding health and safety.
- Always use personal protective equipment.
- Do not deliberately interfere with or misuse health and safety materials.
- Do not deliberately endanger anyone's health and safety.
- Do not deliberately harm yourself.
- Get Involved!
- Get Information: Ask questions and look for information on biosecurity.
- Share and Discuss: Have talks and presentations during school events.
- Work together: Teamwork is always the best work! Activities of one affect all! Only together can we all be safe and secure. One way to achieve that is by joining safety clubs.
- Take the lead and act responsibly: Science should be fun and innovative, not be used to inflict harm. Practice good safety guidelines.
- Make some noise: If you see something, Say something. Call the attention of a supervisor if you suspect a safety or security concern.



HOW TO USE LABORATORY PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) are clothing and work accessories designed to protect the laboratory worker from exposure to hazards caused by chemicals and infectious agents.

When working in the laboratory, always ensure the appropriate use of gloves, wearing of a lab coat, safety glasses, and hearing and respiratory protection.



Ensure working in a biosafety cabinet



Photo Credit: Ikpstudios

GLOSSARY

Biological Agent: A microorganism, virus, particle or otherwise infectious material, either naturally occurring or genetically modified, which may have the potential to cause infection, allergy, toxicity or otherwise create a hazard to humans, animals, or plants.

Biological Materials: An organism or a substance it produces that causes harm.

Containment: The combination of physical design factors and operational practices that protect personnel, the work environment, and the community from exposure to biological agents.

Disarmament: Disarmament is the act of reducing or eliminating access to arms, including nuclear, chemical, biological, radiological and conventional systems.

Dual use items: Certain materials, information and technologies that are intended for benefit but which might be misapplied to do harm.

Epidemic: A disease naturally occurring in a particular region or population.

Hazard: A source, situation, or act with a potential for causing danger.

Pandemics: A pandemic is a disease outbreak that spreads across countries or continents. It affects more people and takes more lives than an epidemic.

Toxin: A toxin is any poisonous substance produced by bacteria, animals, or plants.

Valuable Biological Materials (VBM): Biological materials that require oversight, control, accountability, and specific protective and monitoring measures in laboratories to protect their economic and historical value and/or the population from their potential to cause harm.

Weapons of Mass Destruction (WMD): A weapon of mass destruction is a material capable of inflicting huge casualties or causing destruction to high-value assets.

Zoonotic disease (zoonosis): Infectious disease that is naturally transmitted from animals to humans and vice versa.

ABBREVIATIONS

UNCRC- United Nations Convention on the Rights of the Child

REFERENCES

1. National Research Council (2009). Responsible Research with Biological Select Agents and Toxins. Washington, DC: The National Academies Press. doi: 10.17226/12774
2. United Nations Convention on the Rights of the Child <https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child>
3. Biological Weapons Convention (BWC) and Key Provisions of the Convention <https://www.un.org/disarmament/biological-weapons/>
4. Biorisk management for laboratories and other related organizations ISO 35001:2019 ISO - ISO 35001:2019 - Biorisk management for laboratories and other related organisations
5. Laboratory Biosafety Manual. World Health Organization. 2020 Laboratory biosafety manual, 4th edition (who.int)
6. Biorisk Management – Laboratory Biosecurity Guidance. World Health Organization. 2006 <https://apps.who.int/iris/handle/10665/69390>
7. Hulme, P.E. One Biosecurity: A unified concept to integrate human, animal, plant, and environmental health. *Emerg. Top. Life Sci.* 2020, 4, 539–549.

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