AFRICA CENTRE OF EXCELLENCE IN PHYTOMEDICINE RESEARCH AND DEVELOPMENT UNIVERSITY OF JOS

CHEMICALS AND BIOSAFETY PLAN

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TABLE OF CONTENTS

1. INTRODUCTION

This document has been prepared in accordance with the University of Jos strategic plan on providing a conducive teaching and learning environment, bordering on general safety and security of the workplace particularly in laboratories. It will serve as the Chemicals and Biosafety plan for the African Centre of Excellence in Phytomedicine Research and Development (ACEPRD). It has also been prepared in line with best practices and standards as stipulated by the World Health Organization (WHO) Laboratory Safety Manual (third edition, 2004), the World Health Assembly Resolution on Enhancement of Laboratory Safety (WHA 58.29, May 2005). Also in accordance with OSHA regulations, specifically OSHA 29 CFR 1910.1450(e) - Chemical Hygiene Plan and the Cartagena Protocol on Biosafety to the Convention on Biological Diversity (CBD), Montreal, 29 January, 2000 and ratified by Nigeria on 15, July 2003. The document is in compliance with the National Biosafety Management Agency Bill 2015 passed by the Nigerian National Assembly and signed by the president of the Federal Republic of Nigeria on the 18th of April 2015.

2. PURPOSE

The Chemicals and Biosafety plan for the ACEPRD laboratories specifies the minimum requirements, roles and responsibilities for individuals working with organisms, biological materials, or bio-hazardous materials as well as harmful and toxic chemicals for academic, research and other activities. Emphasis is made towards effectively reducing the risk of injury or illness to laboratory workers and students by ensuring that they have the training, support and equipment needed to work in the laboratory. Furthermore, this policy document provides for a safe and healthy working environment for students, employees and visitors. This document will help to create an environment that will be essential for the ACEPRD to achieve its mission of instruction, research and community service and more importantly govern the activities of the Centre with regard to laboratory practices.

This policy document will be implemented through the following steps:

- developing and improving programs and procedures to assure compliance with all applicable laws and regulations;
- ensuring that personnel are properly trained and provided with appropriate safety and emergency equipment;
- taking appropriate action to correct hazards or conditions that endanger health, safety, or the environment;

- evaluating safety and environmental factors in all operating decisions (including planning and acquisition);
- engaging in sound re-use and recycling practices and exploring feasible opportunities to minimize the amount and toxicity of waste generated.
- using energy efficiently throughout laboratory operations;
- encouraging personal accountability and emphasizing compliance with standards and conformance with University policies and best practices during employee training and in performance reviews;
- communicating the desire to continuously improve on performance and fostering the expectation that every employee, student, and contractor within the University premises will follow this policy and report any environmental, health, or safety concern to the appropriate authorities;
- monitoring progress and implementation through periodic evaluations;
- This policy will also be readily available to all university employees.

3.0 SCOPE

Under the Chemicals and Biosafety Plan, individuals working with organisms, biological material or harmful chemicals must meet all legislative requirements and must adhere to the administrative procedures and operational rules for their acquisition, use, storage, transportation and disposal as set forth in the University's Code of Practice and supporting documentation.

The Chemicals and Biosafety plan applies to all employees, students, contractors and visitors, and will cover all relevant laboratories within the ACEPRD.

Under the Chemicals and Biosafety plan, laboratory employees are meant to comply with the following safety and security policies.

4.1 Security policy

All employees are responsible for safeguarding the ACEPRD resources from unauthorized access, misuse or removal. In the laboratories, this obligation rests primarily with the laboratory technologists. However, all laboratory personnel have a responsibility to take reasonable precautions against theft or misuse of materials, particularly those that could threaten the public. Any extraordinary laboratory security measures should be commensurate with the potential risks and imposed in a manner that does not unreasonably hamper research.

At a minimum, the ACEPRD expects all laboratory personnel to comply with the following security procedures:

- question the presence of unfamiliar individuals in laboratories and report all suspicious activity immediately to the safeguards officer, the head of laboratory and other relevant authority;
- after normal business hours, all laboratories must be locked when not in use. Avoid providing building access to unfamiliar individuals;
- immediately report any building security problem to the appropriate authorities;
- individuals who make requests to use the laboratory or laboratory equipment and who are not directly affiliated with the laboratory must be advised of the potential risks associated with the laboratory and receive training appropriate to the work that will be performed;
- visitors must be accompanied by an individual with authorization to work in the laboratory;
- The risks to vulnerable individuals such as, pregnant women must be evaluated and addressed before they enter or work in laboratories where dangerous materials such as infectious agents, toxins, and dangerous gases, chemicals or radioactive materials are used;

Research or other activities involving the use of laboratory space, materials or equipment without the knowledge and approval of the Head of Laboratory and Environmental Safeguards Officer, and is strictly prohibited. Violation of this prohibition may result in disciplinary action that would be meted out to airing individuals.

4.2 Safety Policy

It is also imperative that the laboratory technologists as well as all relevant laboratory personnel conduct their operations within the laboratory in a manner that would minimise accidents to the barest minimum by adhering to the following guidelines as stipulated by the policy and this would include:

- follow established laboratory safety practices and standard operating procedures;
- verify the performance level and safety of all equipment before use. This includes Personal Protective Equipment (PPE), biosafety cabinets, centrifuges, fume hoods cupboards, autoclave machines and a host of others;
- communicate to the Environmental Safeguards Officer any unsafe practices or conditions in the laboratory;
- report any incidents, chemical spills or accidents involving biological materials, near misses and other potential chemical exposure to the Environmental Safeguards officer;

- inform the Environmental Safeguards Officer of any changes in health status of laboratory workers that may be related to work in the laboratory or that may affect susceptibility to exposure of materials used in the in the laboratory;
- follow procedures and laboratory practices outlined in the ACEPRD Advisory Committee Plan and Laboratory Safety Programs and other protocols as provided by the Centre of Excellence (ACEPRD), through the Environmental Safeguards Officer;
- Prompt reporting of damaged and worn out equipment to the Environmental Safeguards Officer.

5.0 ROLES AND RESPONSIBILITIES

5.1 Environmental Safeguards Officer (ESO)

The ESO shall:

- stay up to date on current safety practices and environmental regulations by attending and participating in all required training workshops, safety courses as well as local and international conferences and/or on-line training;
- conduct exposure monitoring, as needed;
- organise seminars and workshops through the Centre of Excellence (ACEPRD);
- assist employees with establishing and maintaining a safe working environment in both research and teaching laboratories;
- provide consultation for safe working guidelines for laboratory workers;
- review the Biological and Chemical Safety Plan on a regular basis;
- conducts regular laboratory inspections as well as regular fume hood and biological safety cabinet inspections to ensure that standards and containment conditions as stipulated in the Chemical and Biological Safety Plan are strictly adhered to;
- provide consultation for safe work practices for hazardous materials;
- serves as a member of the Chemicals and Biosafety committee;
- develop emergency plans for handling accidental spills and personal containment and investigate laboratory related accidents involving recombinant DNA and other biological agents and chemical exposures;
- report to the relevant authorities any breach in guidelines as well as significant research related accidents or illnesses unless a report has already been filed;

- overall supervision of all laboratory activities, both teaching and research by way of inspection and regular visits to the laboratories to assess the state of facilities, equipment, procedures and practices;
- work with departmental heads and staff to monitor safe procurement, use and disposal of chemicals;
- provide technical advice to all relevant employees as required;
- work with all laboratory employees to facilitate compliance with regulatory guidelines and University's policies;
- File a monthly report with the Centre of Excellence (ACEPRD).

5.2 ACEPRD Advisory Committee

The ACEPRD will constitute an Advisory Committee known as ACEPRD Advisory Committee that would be responsible for monitoring the University's Chemicals and Biosafety Plan as well as providing advice and guidance on policy, procedure and guidelines in support of chemicals and biosafety and legislative compliance. Its members would be drafted from the Centre of Excellence (ACEPRD) team to be chaired by the director of the Centre as well as relevant members of the management team alongside the Environmental Safeguards Officer and tasked with the responsibility of developing this policy. The terms of reference of this committee would be to:

- set-up a programme that would send the relevant staff for trainings, safety courses and conferences to update their knowledge on safety practices;
- registration of all research and teaching programs involving human subjects, animals, recombinant DNA and other biological organisms, chemical agent and materials to ensure the University's compliance with all Federal and State regulations and recommendations pertaining to research in these areas;
- work to create a proactive and positive approach to chemical and biological safety;
- periodically reviewing and updating the Chemical and Biosafety Plan as needed;
- evaluate and document laboratory and field research activities being conducted by the University's faculty, staff and students for safety and health considerations;
- conduct laboratory inspection and audits as a means of supporting on-going measures to ensure that ACEPRD maintains a safe working environment for both research and teaching by rectifying deficiencies identified during such inspections and audits;

- establish safety and health policies in accordance with Federal, State and local regulations;
- facilitate the provision of equipment, and materials needed for laboratory procedures and practices in line with best practices and also provision of standard first aid kits and other necessary personal protective equipment to foster a safe and more efficient working environment for both staff and students;
- investigation of serious accidents and incidents involving bio-hazardous materials and other chemical agents as well as misconduct on the part of staff and students and other serious infractions in line with school rules and regulations;
- keep a record of meetings, providing sufficient detail to serve as a record of major points of discussion and the committee's rationale for particular decisions, documenting that the ACEPRD Advisory Committee has fulfilled its review and oversight responsibilities;
- File an annual report with the University.

5.3 Laboratory Worker (student or staff)

The laboratory's workers responsibilities are to:

- Attend laboratory safety training, seminars and workshops;
- Review the Lab Safety and General Safety manual;
- Follow procedures and laboratory practices outlined in the Chemicals and Biosafety Plan and Laboratory Safety Programs and other protocols as provided by the ACEPRD Advisory Committee;
- Use engineering controls and personal protective equipment, as appropriate;
- Report all incidents, accidents, potential chemical exposures and near miss situations to the Heads of Department and Environmental Safeguards Officer.

6.0 GENERAL LABORATORY SAFETY PROCEDURES

6.1 General Laboratory Safety procedure

The following safety procedures should be followed by all persons in the laboratory:

- Know the materials you are working with (e.g. chemical, biological, radioactive): Refer to written laboratory protocols and review the Material Safety Data Sheets (MSDS) for chemicals. Consider the toxicity of materials, the health and safety hazards of each procedure, the knowledge and experience of laboratory personnel, and the safety equipment that is available;

- Know the location of safety equipment and emergency procedures in your lab;
- Always wear appropriate clothing (e.g. pants, shirts, closed toe shoes) and personal protective equipment (e.g. safety glasses, lab coats, gloves) whenever chemicals are used. Remove personal protective equipment before leaving the laboratory;
- Do not work alone in the building. When hazardous operations are conducted, arrangements should be made to have another person present in the lab;
- Use a properly operating fume hood cupboard when working with hazardous chemicals;
- Do not eat, smoke, drink, chew gum, prepare food or apply cosmetics in the laboratory;
- Keep work areas clean and uncluttered at times;
- Do not leave reactions unattended;
- Unauthorized individuals are prohibited from entering the laboratory;
- Biological Safety Level (BSL-1) is the designated safety level for biological laboratories. Any change from BSL- 1 to BSL- 2 or higher materials must first be reviewed by the ACEPRD Advisory Committee;
- Persons under 16 years of age are prohibited from entering certain high-hazard/high-risk areas (e.g., labs with hazardous chemicals, infectious organisms, or rooms with hydraulic equipment, lasers or radioactive material);
- Non-assistance animals (e.g., not including guide dogs) are not allowed in campus buildings;
- There should always be a high level of awareness and safety consciousness while working in the laboratory.

6.2 Laboratory Safety Training

Training for individuals working in the laboratory must be appropriate for their duties and responsibilities. Training must be provided prior to beginning work in the laboratory and refreshed annually. At a minimum, training will consist of practices to minimize exposure to hazardous material, including the appropriate use of personal protective equipment (PPE's) and the use of laboratory equipment such as centrifuges, biological safety cabinet, fume hood cupboards, autoclave, and other equipment. This can be done through instruction or viewing a safety video therefore, all laboratory safety protocols must be reviewed by both laboratory staff and students. The Centre of Excellence (ACEPRD) will be charged with the responsibility of providing standardized training modules in chemicals handling and biosafety, the use of human subjects in research and laboratory animal use and care. Laboratory technologists should have

their students sign a safety contract. It is the responsibility of the technologists to maintain the safety contracts on file.

6.3 Security

- Laboratory security is an integral part of an effective safety program. Follow these steps to ensure a secure working environment in your laboratory:
- Keep laboratory doors locked when unoccupied;
- Keep stocks of organisms locked during off hours or when the laboratory is unoccupied;
- Keep an accurate record of chemicals, stocks, cultures, project materials, growth media, and other items that support project activities;
- Notify the University's security office if materials are missing from laboratories;
- Inspect all packages arriving at the work area;
- When research is completed for the day, ensure that chemicals and biological materials have been stored properly and securely;
- Ask strangers (someone you do not recognize as a co-worker or support staff person) to exit the room if they are not authorized to be there;
- Other security-specific requirements should be taken into consideration.

6.4 Laboratory Equipment

In newly constructed and renovated laboratories, drench showers, eye washes and fire extinguishers should be located next to the main door of the facility for occupant safety. A hazard (chemical, fire or personal injury) should not come between you and your safe exit from the room. In addition to the aforementioned safety equipment, emergency gas shut-offs and electric panels are located near the exit for access on the way out. It is also pertinent to note that all laboratories should be equipped with these safety mechanisms and devices as well as other relevant laboratory equipment for full functionality of labs and a safer working environment.

6.4.1 Drench Showers

Drench showers and other emergency wash systems are used in an emergency to flush chemicals that have accidentally come in contact with laboratory personnel. In order to wash the body properly, clothing should be removed as water is applied. The drench shower can be used to extinguish a clothing fire, but this is not recommended if the shower is more than a couple of feet away. The best method of extinguishing a clothing fire is to "Stop, Drop & Roll," and then remove clothing. Also, fire alarm systems should be installed within laboratories to

guard against fire outbreaks occurring in the labs. It will be the duty of the schools Physical facilities under the supervision of the Centre of Excellence (ACEPRD) to inspect lab equipment annually for proper functioning and operation. A DO NOT USE notice should be placed on any of the equipment if they are not functioning properly.

6.4.2 Eye and Face Washes

The best treatment for chemical splashes of the eye and face is immediate flushing with copious amounts of water for 15 minutes. Eye and face washes are equipped with a stay-open valve. All plumbed eye and face washes should be flushed by laboratory occupants on a weekly basis by allowing the water to flow for approximately 3 minutes to remove stagnant water from the pipes. Plastic eye wash bottles **are not recommended**.

In general, the emergency eyewash equipment should be installed within 10 seconds walking time from the location of a hazard. The equipment must be readily accessible within the laboratory at a strategic point to avoid going long distances to access it. In addition, the path of travel from the hazard to the equipment should be free of obstruction and as straight as possible.

6.4.3 Sinks and Drains

It is important to ensure that all sinks and drains are properly flushed with abundant quantities of water for about 3 minutes to avoid accumulation of harmful solvents and chemicals that could lead to rust of the sink parts. Also, avoid filling sinks with materials capable of blocking the sinkhole. Only liquid substances are allowed to pass through the sinkholes.

6.4.4 Fire Extinguishers

Fire extinguishers are placed inside or in the hallway outside laboratories depending on the hazards. A dry chemical (BC, ABC) type extinguisher is located in laboratory facilities. While not required, a fire extinguisher can be used by staff that have been trained and feel comfortable using the fire extinguisher in the event of an emergency.

6.4.5 First Aid Kits

First aid kits should be available in each laboratory. According to the American National Standards Institute (ANSI), the kit should contain the following:

Description	ANSI Z308.1 1998	ANSI Z308.1 2003
Minimum Requirements		
Absorbent Square 32 sq in (4”x8” no side < 4”)	1	1
Adhesive Bandages (1”x3”) and Scissors	16	16
Adhesive tape, 5 yd.	1	1
Antiseptic, 0.5g application to include Iodine, Methylated Spirit, etc.	10	10
Burn Treatment, 0.5g application	6	6
Medical Exam Gloves	2 pr	2 pr
Sterile Pads, 3”x3”	4	4
Triangular bandage (40”x40”x56” min)	1	1

These kits should not have additional topical creams, liquids or ointments that can cause further discomfort and/or hinder medical treatment (except in labs using hydrogen fluoride or hydrofluoric acid, which are required to keep 2.5% calcium gluconate on hand for immediate first aid). However, any other relevant item or supplies that are needed for specific needs should be included.

6.4.6 Spill Kits

In laboratories that have hazardous waste satellite accumulation areas, Spill kits should be made available near such accumulation areas and should only be used by those qualified staff with knowledge of the properties and hazards posed by the chemicals, and any potential dangers posed by the location of the spill.

6.4.7 Autoclaves and Incubators

Autoclaves are used at the laboratories within the University of Jos to sterilize glassware and decontaminate biological waste prior to disposal. These autoclaves should only be handled by staff with adequate knowledge on its operations and should be immediately replaced when damaged. See Sections 12.11 and 12.12 for further information regarding biohazard waste disposal and autoclaving procedures.

Incubators are used in the microbiology laboratory, to grow and maintain microbiological cultures and cell cultures. These incubators should also be handled by the appropriate laboratory staff with requisite training and should be properly maintained. It is worthy of note that every piece of equipment to be acquired for use in the laboratories should be of the proper standard and specification for optimum performance and delivery of precise results from experiments carried out.

6.4.8 Sharp Containers and Glass Only Boxes

"Glass Only" boxes are used for the disposal of "clean" broken glass only. When ¾ full, the boxes should be properly sealed, labelled with the building/room number and disposed in a dumpster. "Sharps Containers" and "Glass Only" boxes should be obtained from the right sources.

Sharps containers are used for the disposal of hypodermic needles and syringes, razor blades and other sharp items. Containers for all sharps must be puncture-resistant (**do not use cardboard containers for hypodermic needles**). The sides and the bottom must be leak-proof and they must be appropriately labelled. Containers for disposable sharps must be closable (that is, have a lid, flap, door, or other means of closing the container), and they must be kept upright to keep the sharps and any liquids from spilling out of the container.

The following procedure should be followed for sharps contaminated with infectious waste:

Type of Sharp	Disposal Instructions
Non-hazardous and non- medical sharps (e.g., hypodermic needles and syringes, razor blades and other non-glass sharp items	Collect in puncture–resistant container (e.g. thick-walled laundry detergent bottle). **Make sure that there is <u>NO</u> biohazard symbol or label on the container!** Close and seal when it is ¾ full Label the container "**Sharp Objects Inside – Use Caution when Handling**" Dispose of container in trash
Non-medical Sharps with hazardous chemicals (e.g., hypodermic needles, syringe with needle, Pasteur pipettes, scalpel blades contaminated with formaldehyde, ethidium bromide residual solvents, etc.),	Collect in puncture–resistant container (e.g, thick-walled laundry detergent bottle) Make sure that there is <u>NO</u> biohazard symbol or label on the container! Close and seal when it is ¾ full Put a **hazardous waste label** on the container and list the hazardous constituents and label the container "**Sharp Objects Inside – Use Caution when Handling**" Dispose of as a hazardous waste--contact ESO or place in Hazardous Waste Satellite Accumulation Area

Medical/infectious sharps (e.g., hypodermic needles, syringe with needle, Pasteur pipettes, scalpel blades). Infectious wastes include human blood, human tissues, etc. and infectious organisms, genetically altered living organisms, live or attenuated vaccines, and certain types of recombinant DNA (see Section 12.6.	Collect waste in a puncture-resistant sharps container labelled with the **biohazard symbol or appropriately color-coded**. When ¾ full, place the sharps container into a red biohazard bag. Dispose of the biohazard bags into a biological burn box that has been lined with a second biohazard bag. Contact ESO to arrange for proper disposal.
Medical/infectious sharps with hazardous chemicals	Collect waste in a puncture-resistant sharps container labelled with the **biohazard symbol or appropriately color-coded**. When ¾ full, place the sharps container into a red hiohazard bag. Put a **red hazardous waste label** on the container and list the hazardous constituents and label the container "**Sharp Objects Inside – Use Caution when Handling**" Contact ESO to arrange for proper disposal.

6.4.9 Mechanical Pipetting Aids

Mechanical pipetting aids should be used. **Mouth pipetting is prohibited**.

6.5 Laboratory Safety Information

MSDS, emergency procedures, safety manuals and other references should be readily available for all laboratory personnel.

6.5.1 Laboratory Safety Door Postings

A "caution" sign will be posted on or near the entrance door to the laboratory and the sigh will include;

- The type of activities carried out in the laboratory;
- The biosafety level of the laboratory for biological laboratories;
- A listing of the hazards associated with work in the laboratories (infectious agents, toxins, corrosive as well as flammable chemicals, and radioactive materials if any);
- The names and contact information of responsible faculty member, environmental safeguards officer, laboratory technologists and other relevant persons to be contacted in the event of an emergency.

In addition to cautions posted at the entrance to the laboratory, appropriate universal warning signs or symbols shall be placed on all freezers, refrigerators, centrifuges, incubators, autoclaves, waste containers and biohazard signs where hazardous materials are used and stored. Signs should be reviewed by the environmental safeguards officer in collaboration with the relevant heads of department and laboratory technologists at least annually or in the event that pertinent information changes. Contact the HODs' or the ESO to request a new sign.

6.6 Using Acetone to Wash Glassware

The following steps should be followed for washing glassware used to prepare chemical solutions:

- Put on safety glasses and gloves.
- Dispose of any residual contents within the glassware according to established protocols (follow protocol for disposal of hazardous waste). When pouring liquids into hazardous waste containers ensure that a funnel of adequate size is used to minimize spills or splashing;
- Check to determine if acetone is compatible with the material formerly contained in the glassware. Only proceed to step 4 if acetone is compatible;
- Using a squeeze-bottle labelled "acetone", gently rinse the glassware with acetone so that all surfaces of the glassware have been rinsed. Glassware must be rinsed thoroughly, while using the least acetone possible, as it must also be disposed of as a hazardous waste. Either collect the acetone rinsate into the funnel to the hazardous waste container OR for large amounts of glassware collect the acetone into the labelled tub with drainage spout dedicated to this purpose;
- Dispose of all acetone rinsate into the appropriately labelled hazardous waste container;
- Wash the glassware with soap and water, and rinse several times with distilled water. Alternatively, use departmental automatic dishwashers if available;
- If necessary to eliminate water molecules for chemical reasons, rinse again with acetone, following steps 4 and 5.

6.7 Laboratory Inspections/Surveys

The ESO with the backing of the Centre of Excellence (ACEPRD), University of Jos. surveys laboratories annually. Laboratory visits may also be conducted following the report of a safety-related incident Lab inspection forms are available from the ESO. Additional safety surveys are conducted where hazardous waste is stored. Following the laboratory safety survey, a report listing the hazard(s) is sent to the Heads of Department responsible for the laboratory.

The department is responsible for correcting the operational hazards through the University authorities responsible for correcting all infrastructure deficiencies. This will be done in conjunction with the Centre of Excellence (ACEPRD). Follow-up surveys are conducted in laboratories with extremely hazardous conditions and/or numerous violations. The ESO will also periodically conduct a biohazard evaluation of all laboratories to insure that appropriate facilities and procedures are being used.

In addition to these annual laboratory safety surveys, laboratory personnel should maintain an updated list of new chemical inventory for the ESO and should periodically conduct their own safety inspections.

7.0 P E R S O N A L PROTECTIVE EQUIPMENT

7.1 Personal Protective Equipment Policy

The following personal protective equipment must be available for laboratory personnel and students who are working with hazardous materials. Laboratories must provide personal protective equipment (i.e. safety glasses, laboratory coat) for visitors and post a sign indicating that eye protection is required where hazardous materials are in use.

Personal protective equipment will be supplied by the University and will be in line best standards and the Centre of Excellence through the ESO will assist with recommendations on specific types and uses of protective equipment.

7.2 Eye and Face Protection

Eye and face protection must be worn in the laboratory when there is a potential for contact with hazardous chemicals or other agents (e.g. non ionizing radiation, bio-hazardous materials, aerosolized material, flying objects). All protective eye and face wear should meet ANSI Z87.1-1998 and ANSI Z136.1-2000 standards. The type of protection needed depends on the hazard (e.g. chemical, ultraviolet light, laser, impact). For instance, when laboratory chemicals are used, approved eye protection is mandatory and chemical splash goggles are recommended. Goggles should be worn over eyeglasses, or prescription safety glasses with side shields should be worn. Ordinary prescription glasses do not meet these standards. Likewise, contact lenses, by themselves, do not provide adequate protection in any environment in which the chance of an accidental splash of a chemical can reasonably be anticipated. Appropriate eye protection should always be worn in such situations. Face shields should be worn when working with an agent that may adversely affect the skin on the face and/or when proper eye protection is not enough.

Eye, skin and face protection are required when working with severely corrosive or strongly reactive chemicals, with glassware under extreme pressures, in combustion and other high temperature operations and whenever there is a possibility of an explosion or implosion. Special safety glasses and face shields are required for work with UV light, lasers and other types of radiation, which is absorbed by the eyes and skin (chemical splash goggles are not adequate for these types of work).

7.3 Laboratory Coats, Gloves and Other Protective Clothing

Laboratory coats and shoes should be worn when performing laboratory work **(open toed- shoes, sandals, flip-flops, clogs, etc. are prohibited)**. Depending on the type of work, additional personal protective equipment, such as gloves and aprons may be necessary. Coats, aprons and gloves should be removed when leaving the laboratory. Use non-latex gloves, such as nitrile or vinyl. Gloves should be replaced immediately if they are contaminated or torn. In situations involving extremely hazardous chemicals, double gloves are recommended. Gloves should be carefully selected for their degradation and permeation characteristics to provide proper protection. The thin, vinyl or nitrile gloves, popular for their dexterity, are not appropriate for highly toxic chemicals or solvents. It is essential to choose the right kind of glove for specific chemicals or activities.

7.4 Respiratory Protection

The use of air-purifying respirators for routine laboratory work is not recommended. Respirators are discouraged because they protect only the wearer and require periodic medical monitoring, specific training and fit testing before they can be worn effectively. Properly operating laboratory fume hoods provide the best overall protection from chemical hazards in the laboratory, and it must be used properly either by lab employees or students with adequate training.

Facemasks are loose-fitting, disposable masks that cover the nose and mouth. These include products labelled as surgical, dental, medical procedure, isolation, and laser masks. Facemasks help stop droplets from being spread by the person wearing them. They also keep splashes or sprays from reaching the mouth and nose of the person wearing the facemask. **They are not designed to protect you against breathing in very small particles**. If for any reason facemasks should be worm, it should be used once and then thrown away in the trash.

7.5 Protective Clothing beyond the Laboratory

All, protective clothing that is contaminated, potentially contaminated or could be perceived as contaminated (e.g. Gloves, safety glasses, lab coats and other personal protective

equipment) that is brought outside the laboratory may create a hazard or project a careless image to both colleagues and visitors.

- Wearing gloves outside the lab should be minimized, except to move hazardous materials between laboratories. Instead, transport chemicals from place to place on a cart, in a clean secondary container, or in a bottle carrier with secure handles;
- If there is a need to transport hazardous materials, use a clean, ungloved hand to touch common surfaces and a gloved hand to carry the items: the one-glove rule. Alternatively, package the material so it may be handled without gloves;
- Gloves should never come in contact with door handles, elevator buttons, telephones, lavatory faucets, vending machines, bottled-water dispensers, ice-making machines, or other surfaces outside the laboratory;
- For the sake of safety, appearances, and courtesy, please do not wear contaminated, stained, or potentially contaminated lab coats and other research clothing and equipment outside of the laboratory.

8.0 VENTILATION

8.1 Laboratory Ventilation Policy

All work with hazardous materials must be conducted in the appropriate fume hood. General room ventilation does not provide adequate protection against hazardous gases, vapors and aerosols. All work with corrosive, flammable, odoriferous, toxic or other dangerous materials shall be conducted only in a properly operating hood or glove box. When it is not possible to meet the above requirements, the Head of Laboratory, ACEPRD Advisory Committee, and ESO must evaluate hazards together to determine if work can be conducted safely, or if a necessary replacement will be made.

8.2 Fume Hoods

Fume hoods are checked annually (coordinated by ESO). The velocity of the air at the face of the hood is measured with the sash half-open and the results are posted on a sticker, which is attached to the upper right-hand corner of the sash. Variable air volume (VAV) hoods maintain a constant face velocity at different sash heights. Generally, when conducting experiments, researchers should have the sash closed as much as possible. Hoods that do not meet the minimum exhaust requirements during safety inspections are posted with "DO NOT USE" notes and Physical facilities is notified about the need for repairs. Once repairs have been made, the ESO will test the fume hood for proper operation.

8.2.1 Procedures for Proper Use of Fume Hoods

Before using the hood, make sure air is entering the hood and the hood is functioning properly. Report any problems to Physical Plant. Do not block baffle openings or place bulky items in the hood that will prevent air from entering the baffle opening.

- Ensure that air is entering the unit;
- Ensure the baffle openings are not blocked and air is flowing properly;
- Conduct work at least six inches from the edge of the hood;
- Lower the sash to protect yourself from dangerous reactions;
- Keep hood clean and uncluttered. Wipe up spills immediately;
- Be aware that drafts from open windows, open doors, fans, air conditioners, and high traffic walkways may interfere with normal hood exhaust;
- Always open a chemical bottle under the fume hood so that the fumes inside the bottle will not leak into the laboratory where users will breathe them;
- Always recap chemical bottles immediately after use. Never leave an uncapped bottle under the fume hood. After recapping, immediately restore the bottle to its appropriate storage.

8.2.2 Fume Hood Alarms

Fume hood alarms indicate sub-standard operation of fume hoods. The fume hood alarm (audio/visual) will indicate an exhaust flow malfunction by an audio and visual alarm. If the fume hood alarm sounds, close the sash and notify Physical Facilities. Do not use the fume hood until repairs have been made and the ESO has removed the "Do Not Use" sign.

8.3 Vertical Laminar Flow Clean Air Wet Process Fume Hood

Adequate provisions should be made by the ACEPRD for the acquisition of polypropylene vertical laminar flow wet process fume hood. This hood is designed to protect the user from hazardous fumes typically associated with acid digestion, while creating clean environments that are required for trace metal analyses that require metal-free environments. The air, as supplied to the work area through High Efficiency Particulate Air (HEPA) filters from the top of the cabinet, is contaminant free, and the airborne contamination generated in the work area is controlled by the unidirectional flow of parallel air streams in a top-to-bottom direction.

- **Plan the experiment or procedure:** to minimize the number of times an operator's hands and arms must enter and leave the air curtain at the open face. All necessary

equipment for the complete procedure should be placed in the hood before starting, so that nothing passes in or out through the air barrier until the procedure is completed. This is especially important when working with moderate risk agents.

- **Minimize the number of items:** inside the cabinet to prevent overloading. A solid object placed in a laminar air stream will disrupt the parallel flow and consequently, the capability of controlling lateral movement of airborne particulates. A cone of turbulence extends below the object and linearity of the air stream is not regained until a point approximately three to six times the diameter of the object downstream. Within the parameters of this cone, particles may be carried laterally by multi-directional eddy currents.
- **Avoid unnecessary raising of the hands:** inside the cabinet above the level of the work opening. This presents an inclined plane from hands to elbows along which the down-flow of air may run to and possibly out of the open face.
- **Always use motions parallel to the inflow velocity**: straight in, straight out. Never use horizontal sweeping movements when withdrawing hands from the cabinet.
- **Minimize activity in the room:** A person walking past the front of a cabinet can cause draft velocities that are sufficient to disrupt the air balance of the laminar flow unit.
- **Minimize blockage of front/rear inlet grills:** Arms should be kept above the front inlet grill, and lab coats should be tight fitting and not permit blocking of the suction inlet grill. Blocking the rear grill will alter the airflow pattern and could result in cross contamination of the work in process. Excessive blocking of the rear grill will force more air toward the front grill and lower the personnel protection afforded by the cabinet

8.4 Biolgical Safety Cabinets

It is essential that Biological safety cabinets are installed in microbiology laboratories. At a minimum, a class I and class II cabinet should be installed. Open-fronted Class I and Class II biological safety cabinets are primary barriers which offer significant levels of protection to laboratory personnel and to the environment when used with good microbiological techniques. The Class II biological safety cabinet also provides protection from external contamination of the materials (e.g., cell cultures, microbiological stocks) being manipulated inside the cabinet.

All Class II cabinets are required to provide personnel, product and environmental protection from particulate contaminants. Regardless of cabinet Class or Type, it is important to remember that HEPA filtration traps particulates only, and is completely porous to gases and

vapors. It is essential that the user understands the proper functioning of all cabinet types to avoid damage to the equipment and harm to personnel working with the BSC. It is important to note that BSC's do not provide the same level of protection as a chemical fume hood when working with volatile or other hazardous chemicals and should not be used as a substitute for a chemical fume hood. Similarly, a chemical fume hood will not provide adequate protection when working with infectious agents and other hazardous biological agents. Consequently, toxic volatile chemicals are prohibited inside a BSC. To ensure safety, BSCs must be used correctly with good microbiological techniques and be in proper mechanical working order. Cabinets must be certified for performance upon installation using *National Sanitation Foundation (NSF) Standard #49, Section 6*. Recertification must be conducted annually or during the interim if the cabinet is moved or if a problem is suspected. Certification information will be made available by the ESO.

Flammable gas should not be used in a re-circulating BSC. If a gas leak occurs (e.g. valve left on or tube leak) inside a recirculating biological safety cabinet, over time the gas would become more concentrated and could reach explosive levels. Because it is within a BSC, the user may not detect the leak and, upon ignition, it could explode. Therefore, natural gas or other flammable gases should not be used within recirculating biological safety cabinets.

Do not use an open flame in the BSC as the open flame will reduce the efficiency of the BSC. Open flames are not required in the near microbe-free environment of a biological safety cabinet. On an open bench, flaming the neck of a culture vessel will create an upward air current which prevents microorganisms from falling into the tube or flask. An open flame in a BSC, however, creates turbulence which disrupts the pattern of HEPA-filtered air supplied to the work surface. When deemed absolutely necessary, touch-plate micro-burners equipped with a pilot light to provide a flame on demand may be used. Ultraviolet lights should be routinely checked and replaced as needed.

Cabinet blowers should be operated at least three to five minutes before beginning work to allow the cabinet to "purge". This purge will remove any particulates in the cabinet.
The BSC should be decontaminated frequently and after work is complete. The work surface, the interior walls (not including the supply filter diffuser), and the interior surface of the window should be wiped with 70% ethanol (EtOH), a 1:100 dilution of household bleach (i.e., 0.05% sodium hypochlorite), or other disinfectant as determined by the investigator to meet the requirements of the particular activity. When bleach is used, a second wiping with sterile water is needed to remove the residual chlorine, which may eventually corrode stainless steel

surfaces. Wiping with non-sterile water may re-contaminate cabinet surfaces, a critical issue when sterility is essential (e.g., maintenance of cell cultures). Similarly, the surfaces of all materials and containers placed into the cabinet should be wiped with 70% EtOH to reduce the introduction of contaminants to the cabinet environment. This simple step will reduce introduction of mold spores and thereby minimize contamination of cultures. Further reduction of microbial load on materials to be placed or used in BSCs may be achieved by periodic decontamination of incubators and refrigerators.

9.0 EMERGENCIES, SPILLS, & ACCIDENTS

The ACEPRD has developed this Chemicals and Biosafety plan that also highlights in detail, emergency response procedures and evacuation plans in order to inform faculty, staff, students, and visitors of the appropriate procedures to be followed in the event of an emergency. This program contains information on what is considered an emergency, and who should be contacted. In the event that there is a high level of uncertainty on how to categorize a situation, it is recommended to always act conservatively with consideration of human health and safety. In the case of an emergency in a particular lab, the head of lab should be contacted or the ESO and any other relevant authority.

9.1 Preparation

The first step in any emergency procedure is to be prepared by knowing the hazards of the various materials in each lab. Review the MSDS's on materials used in the lab, and review with students their responsibilities in the event of a chemical spill or fire. Material safety data sheets should be available to students and visitors who have concerns or questions regarding the hazardous characteristics of the chemicals.

Chemical containers should be clearly labelled with the contents and any required hazard warnings. Labs should have appropriate signage on the door indicating the predominant hazards in each room and emergency contact information.

9.2 Fire or Explosion

In the event of a fire or explosion:

- Evacuate the fire area. Turn off the emergency gas shutoff if it is safe to do so;
- Close the door behind you;
- If someone is on fire, put them under the emergency shower or locate the fire blanket if there is any available, direct the person to Stop Drop and Roll and use the blanket to cover the person to snuff out the flames. Seek assistance;

- Notify nearby occupants and pull the fire alarm to activate the building alarm system, if it has one. Such systems are vital and should be installed;
- Proceed in an orderly fashion to the nearest exit. If there is smoke, stay low to the ground as smoke and heat will rise;
- Inform the relevant authorities and report the location of the fire and any additional information.

9.3 Emergency Gas Shut off Protocol

- The default condition for the gas shutoff valve will be the "Off" position with the door locked;
- Keys for the shutoff will be issued to faculty or staff with lab responsibility and a copy kept in the HOD's office;
- When use of gas is required, the lab instructor will check that gas jets on the benches are in the "Off" position, unlock the shutoff cabinet, and turn the gas "On." Gas use in most laboratories is rare;
- The door to the shutoff valve will be kept open and unlocked during lab, to allow the gas to be turned off in case of emergency;
- At the conclusion of the lab, the lab instructor will check that gas jets are off, turn off the lab gas shutoff valve, and lock the door;
- This procedure will be included in the orientation of all lab instructors, and students will be instructed on how to turn lab gas off in an emergency.

9.4 Medical Emergency

Serious injuries that require an ambulance should be reported to the campus clinic immediately. Serious injuries include but are not limited to: chest pain, difficulty in breathing, unconsciousness, large area of body contacted by a hazardous chemical, broken bone or profuse bleeding. Very minor (first aid) injuries can be addressed via use of first aid kits within the lab.

For any type of injury or "near miss", the lab instructor should complete an "Incident Report" to determine what happened and what can be done to prevent recurrence.

9.5 Chemical Spills

9.5.1 Minor Chemical Spill

A minor chemical spill is considered one that laboratory staff or departments are capable of handling safely without assistance and where there is no injury or threat of imminent injury. Typically, a minor spill would be considered less than 0.5 liter (as a rule of thumb) of a material

that is not highly toxic. Spill kits are available in each laboratory and should only be used by those qualified staff with knowledge of the properties and hazards posed by the chemical, and any potential dangers posed by the location of the spill. Spill cleanup materials should be segregated for hazardous waste disposal. The ESO should be contacted for advice and assistance. The basic procedures are as follows:

- Only qualified persons knowledgeable of the material(s) spilled should perform the clean-up;
- Alert all persons nearby spill area;
- Use eyewash or safety shower if needed to decontaminate;
- Use spill kit to clean up and segregate clean up materials for hazardous waste disposal;
- Use proper personal protective equipment, which at a minimum will include chemical resistant gloves and safety glasses;
- Decontaminate spill area with water or soap/water mixture if a non-reactive chemical;
- Wash hands thoroughly and seek medical attention if necessary;
- Save the spill clean-up materials containing hazardous materials for proper disposal;
- Proper documentation should be made and filed for record purposes.

9.5.2 Major Chemical Spills

- All other spills not described above are considered major spills. For major spills, the following procedures should be followed:
- Avoid breathing vapours of spilled material;
- If possible and safe to do so, turn off any ignition source or gas emergency shut-off valve;
- Remove any contaminated persons from spill area and decontaminate via eyewash or safety shower. The use of a safety shower is never a mistake – do not be reluctant to use the shower in the event of personal chemical contamination.
- Evacuate the area and close the door to the lab;
- Post a sign stating “Hazard – Do Not Enter” on the exterior surface of the door once all personnel are evacuated, if safe to do so;
- Contact the Head of Department or the Environmental Safeguards officer for appropriate action.

9.6 Biological Spills

The proper procedures to deal with biological spills vary depending on the agent, quantity and location of the event. However, in order to quickly clean-up a biological spill, the laboratory should keep a spill kit handy. A spill kit should include:

- Concentrated disinfectant (chlorine, bleach or Lysol).
- Packages of paper towels.
- Forceps to pick up broken glass.
- Household rubber gloves.
- Utility gloves.
- Several waste collection bags.

The basic procedure for a biological spill includes:

- Place paper towels over the spill area. Wear chemical resistant gloves and safety glasses.
- Soak paper towels with disinfectant;
- Allow paper towels to stand for 15 minutes contact time;
- Place towels in plastic bag for disposal and notify the HOD or ESO for further instructions;
- Clean spill area with fresh disinfectant and paper towels. Place in plastic bag;
- Dispose of the materials properly;
- Wash hands thoroughly and seek medical attention if necessary;
- Spill should be properly documented for record purposes.

9.6.1 Spills in a Biological Safety Cabinet

- Leave the cabinet turned on;
- While wearing gloves, spray or wipe cabinet walls, work surfaces and equipment with disinfectant. If necessary, flood the work surface, as well as drain pans and catch basins below the work surface, with a disinfectant for at least 20 minutes contact time;
- Soak up the disinfectant and spill with paper towels;
- Drain the catch basin into a container;
- Lift front exhaust grill and tray and wipe all surfaces. Ensure that no paper towels or solid debris are blown into the area beneath the grill;
- Autoclave all clean-up materials and protective clothing;
- Wash hands and exposed skin areas with disinfectant.

9.6.2 Spills Outside of a Biological Safety Cabinet

Biological Level (BSL) 1 spills can be cleaned up using basic personal protective equipment and a disinfectant solution such as a bleach solution.

Small spill of BSL-1 material outside of a safety cabinet (<500 ml spill and able to be covered by a few paper towels):

- Wearing gloves and a lab coat, cover the spill with paper towels and an appropriate disinfectant;
- Allow sufficient contact time with disinfectant (at least 15 minutes);
- Pick up towels and discard into biological waste container;
- Pick up broken glass with forceps and place in sharps container;
- Re-wipe the spill area with disinfectant and wash your hands with soap or hand washing disinfectant.

Large spill of BSL-1 material outside of a safety cabinet (>500ml) will still be taken care of using the same procedure for small spills.

9.6.3 Blood (From Injury)

Use the following Personal Protective Equipment (PPE) to protect against human blood:

Gloves	Worn for touching blood and body fluids requiring universal precautions, mucous membranes or non-intact skin of all patients and for handling items or surfaces soiled with blood or body fluids to which universal precautions apply.
Masks, eye protection, face shields	Worn to prevent exposure of mucous membranes of the mouth, nose and eyes during procedures that are likely to generate droplets of blood or body fluids requiring universal precautions.
Lab coats, gowns, Aprons	Worn during procedures that are likely to generate splashes of blood or body fluids requiring universal precautions.

- Wearing household gloves, face protection, and a lab coat, absorb blood with paper towels;
- Using a detergent solution, clean the spill site of all visible blood;
- Wipe down the spill site with paper towels soaked in a disinfectant such as chlorine bleach, diluted 1:10;

- Double-bag all contaminated materials in plastic bags or container and discard in trash If the materials are completely saturated notify ESO for proper disposal procedures;
- Wash your hands with soap or hand washing disinfectant.

10.0 EMPLOYEE MONITORING AND RECORD KEEPING

University of Jos works primarily with chemicals and biological agents that are well characterized and not known to consistently cause illness or disease in immune-competent adult humans, and present minimal potential hazard to lab personnel or the environment. However, personnel who work routinely in biological and chemical laboratories may require medical surveillance, depending on the nature of their research, including:

- Chemical and physical hazards.
- Personal hygiene as related to work with animals.
- Zoonoses and other biohazards.
- Other occupational hazards, including bites, allergies, and considerations for pregnant women.

Local exhaust ventilation systems such as chemical fume hoods and glove boxes are the preferred and primary method of controlling exposures to hazardous chemicals in the laboratory. Assuming that the fume hoods and other appropriate methods of containment are used properly and whenever needed, safe work practices are followed judiciously, and all laboratory and support personnel practice good personal hygiene, the need for routine monitoring of airborne contaminants in the laboratory is unnecessary and impractical. When a concern does arise over potential exposure to a laboratory chemical or biological hazard, contact the HOD or ESO for assistance. As required by the laboratory standard, exposures to OSHA regulated chemicals in the laboratory must not exceed the Permissible Exposure Limits (PELs) or the recommended Threshold Limit Values (TLVs) when there is no PEL. The following website contains the complete list of OSHA-regulated chemicals:

In addition, if you work with any of the following materials on a regular basis, contact ESO to arrange for exposure assessment and air monitoring:

2-acetylaminofluorene	bis-chloromethylether	Methylchloromethylether
Acrylonitrile	1,2-dibromo-3-chloropropane	Methylenebischloroaniline
4-aminodiphenyl	3,3'-dichlorobenzidene	Methylenedianiline
Arsenic	4-dimethylaminoazobenzene	α and β-naphthylamine
Asbestos	Ethyleneimine	4-nitrobiphenyl
Benzene	ethylene dibromide	N-nitrosodimethylamine
benzidine (and salts)	ethylene oxide	β-propiolactone
1,3-butadiene	formaldehyde/formalin	vinyl chloride
Cadmium	Lead	

Initial monitoring shall be performed if there is reason to believe that exposure levels for a substance routinely exceed the action level (or in the absence of action level, the permissible exposure level (PEL) or in some cases, the short-term exposure level (STEL)).

Special note on pregnancy: Personnel who are pregnant or considering becoming pregnant may have special concerns about working with chemicals that have potential reproductive hazards. Such concerns can be discussed with their head of lab and ESO. All inquiries are confidential. Disclosure of pregnancy is not mandatory that early consultation with a medical professional, as the first trimester is an important phase in pregnancy.

10.1 Medical Consultation and Medical Examinations.

Medical and work history documentation and pre-work assignment medical work history review may be required prior to working with certain chemicals and/or vertebrate animals. Physical examinations may be performed (at the discretion of the attending physician)—including pre- work physical examination, subsequent periodic physical examinations as required for individuals in some job categories, and pre-work assignment immunizations and booster injections against tetanus and other diseases to which animal care personnel might be exposed.

Medical consultation and evaluation should be made available to all ACEPRD employees. Contact the ESO to discuss potential occupational exposures or to request a consultation with a doctor through the ACEPRD Advisory Committee.

In general, medical follow-up is required:

- In the event of a spill or an event that results in an acute chemical or biological exposure;
- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory;
- When exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance.

10.2 Vaccinations

10.2.1 Employees

Any researcher who plans to work with human bodily fluids or other potentially infectious material must provide documentation of all immunizations (or positive titer) for hepatitis B to the Environmental Safeguards officer prior to initiating any research activities.

Note: The University of Jos will make the hepatitis B vaccine and vaccination series available to all employees who have occupational exposure, and post-exposure evaluation and follow-up to all employees who have had an exposure incident. However, for scientific research involving work with human bodily fluids, the faculty member or researcher who chooses to conduct this research must receive prior approval and seek appropriate funding for the appropriated immunizations.

10.2.2 Student Researchers

Documentation of all immunizations (or positive titer) for hepatitis B for students are kept on file at the University Health Centre. It is the responsibility of the student to provide this documentation to the ESO and/or the academic supervisor.

10.3 Reporting of Illnesses or Injuries

All work-related illnesses or injuries must be reported immediately to the employee's supervisor and within twenty-four hours to the ESO. These include, but are not limited to:

- Animal bites.
- Unprotected exposures, including needle punctures to infectious agents.
- Unprotected exposures to carcinogens and similar high-toxicity materials or any other hazardous materials.

For more information, and to obtain a copy of the Incident Report Form see Appendix C Illnesses suspected of being related to work with animals will also be reported to appropriate public health officials and medical personnel.

10.4 Periodic monitoring:

If the initial monitoring performed discloses employee exposure over the action level (or in the absence of action level, the PEL and/or the STEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard. Within 15 working days after the receipt of any monitoring results, the employee will be notified of these results in writing either individually or by posting results in an appropriate location that is accessible to employees. Anyone with a "reason to believe that exposure levels for a substance routinely exceed the action level, or in the absence of an action level, the PEL or STEL" may initiate the monitoring process. Requests for monitoring should be made through the ESO and supervisor.

10.5 Records

10.5.1 Medical Records

Confidential medical records are maintained for employees and students receiving medical surveillance and medical care at the University Health Centre or other designated health care facility (contact the ESO for more information).

10.5.2 Training Records

Training records include the following information:

- Date of training session.
- Contents or summary of the training.
- Name of person attending the training.
- Names of persons conducting the training.

Records for trainings to be organized by the Centre of Excellence (ACEPRD) are maintained in the ACEPRD office. Copies can be forwarded to the Heads of Department upon request.

11.0 GENERAL CHEMICALS HANDLING

11.1 Chemical Procurement and Distribution

- Plan experiments with safety in mind. Substitute less hazardous chemicals in laboratory procedures when possible. Examples include substituting methyl tertiary-butyl ether (MTBE) for ethyl ether, toluene for benzene, and dichloromethane for chloroform and carbon tetrachloride;
- Only purchase what you can reasonably expect to use during the next six (6) months;
- Less is Better When possible, buy what you specifically need. It is often possible to buy pre-made molar and normal solutions, thereby reducing the likelihood of waste;

- Before ordering new chemicals, estimate the amount of chemical required for each experiment and order only what is necessary. Excess chemicals are very expensive to dispose of and can cause a hazard if stored too long;
- Glass breaks. When available, purchase chemicals in plastic containers. If this is not possible, purchase shatter resistant plastic coated bottles;
- Read labels. Most of what you will need to know about how to handle and store the chemical is found on the manufacturers' label or in the Material Safety Data Sheet (MSDS), at or through a chemical vendor;
- Indicate the date received and the date opened on the container. Pay particular attention to expiration dates - especially peroxide-forming compounds;
- Keep your chemical inventory and your emergency signs updated. Before opening a package containing hazardous substances, inspect the packaging carefully for any signs of breakage or leakage of material. If there are any signs of leakage, place package in chemical fume hood, protect from exposure and call the ESO for assistance;
- After removing chemicals from the packing material carefully compare the number and identity of items against the packing slip before disposing of the packing materials.

11.2 Chemical Storage

The number and amounts of chemicals that need to be stored should be reduced to an absolute minimum. Physically segregate your chemicals into their respective hazard categories—corrosive, flammable, reactive, and toxic. Chemicals should be stored based on their compatibility; compatible chemicals can be stored alphabetically. Acids, flammable liquids, oxidizers, and highly reactive chemicals should all be separated and stored properly to avoid an unwanted chemical reaction.

A simple way to ensure that your materials are stored properly is to check the packaging label and/or MSDS to determine the primary hazard, especially for chemicals that have more than one hazard. Each hazard class and each class within a hazard class must be segregated from each other as follows:

DOT Hazard Classes	DOT Symbol	Division	Examples and special notes
Class 1: Explosives			Not used at University of Jos
Class 2: Gases		2.1 Flammable gases	Hydrogen, methane
		2.2 Non-Flammable gases	Helium
		2.3 Poisonous gases	Not used at University of Jos
Class 3: Flammable liquids		Halogenated	Chloroform, methylene chloride, tetrachloroethylene, trichloroethylene, 1,1,1-trichloroethane
		Non-halogenated	Acetone, alcohols, benzene, formaldehydes, toluene, methanol, methyl ethyl ketone, methylisobutyl ketone
Class 4: Flammable solids		4.1 Flammable solids	Aluminum powder
		4.2 Spontaneously combustible	Aluminum alkyls
		4.3 Dangerous when wet	Sodium, magnesium, phosphorus, barium
Class 5: Oxidizers		5.1 Oxidizers	Oxygen cylinders, sodium hypochlorite, chlorine gas
		5.2 Organic peroxides	Not used at University of Jos
Class 6: Poisons		6.1 Poisons (Toxic)	Arsenic, barium, cadmium, cyanide

		6.2 Infectious Substance	Not used at University of Jos

DOT Hazard Classes	DOT Symbol	Division	Examples and special notes
Class 7: Radioactive materials			Not used at University of Jos
Class 8: Corrosives		Inorganic acids	Sulfuric acid
		Oxidizing acids	Nitric acid, perchloric acid (not permitted at University of Jos)
		Hydrofluoric acid	Hydrofluoric acid
		Organic acids	Acetic acid, citric acid, formic acid, oxalic acid
		Bases	Ammonia, hydroxides
Class 9: Other hazardous materials			Can be stored with Class 6 (Poisons)

General guidelines:

- Label the secondary storage containers or areas in which particularly hazardous chemicals may be used. These substances must be kept in a designated area;
- Corrosive, flammable and reactive chemicals should be located below eye level. This simple task greatly reduces the likelihood of something falling from above and breaking;
- Cabinets with doors are safer locations than open shelves for hazardous chemicals.
- Avoid placing any chemical container in direct sunlight, underneath a sink, or near heat sources;
- Storage areas should be well ventilated (consult with the ESO);
- Large containers of reagents should be stored on low shelving, preferably in trays to contain all leaks and spills;
- Chemicals should never be on the floor;
- Chemicals should only be on bench tops or inside fume hoods when in use;
- Inventories of storage areas will are conducted on an on-going basis by the ESO. Inventory is posted on the ACEPRD web application;
- Be especially careful with reactive chemicals. Obtain and read the MSDS for each reactive chemical that you may have or may work near. Reactive chemicals should be stored according to the manufacturer's instructions;

- Never place open containers containing volatile or flammable chemicals in ordinary, household-style refrigerators. Flammables requiring refrigeration should be stored in a flammables storage refrigerator;
- A list of incompatible chemicals is provided in Appendix E. This list should be used only as a guide-specific incompatibilities are listed in the MSDS.

11.3 Labeling Chemicals

The identification and disposal of un-labelled chemical containers is very expensive. Please label all containers in the laboratory with the following information. This includes any stock or working solutions:

- Name of chemical or stock solution.
- Date the chemical was received opened or prepared (for working solutions).
- Full name of responsible faculty or staff (not simply student name or initials).
- Hazard warning (i.e., flammable, toxic, corrosive, reactive).

Labels on incoming containers must not be removed or defaced. Dating is required for certain materials; dating the label is especially important in the case of compounds which have a specified shelf life, such as those that will form peroxides (e.g. ethyl ether). All laboratory personnel who are leaving the College are responsible for identifying and properly disposing of the chemical waste in their laboratory. Contact the ESO for additional information.

11.4 Chemical Inventory

The OSHA Hazard Communication Standard stipulates that an inventory of hazardous chemicals will be registered and documented. A hazardous chemical is defined as any liquid, solid, or gas that could present a physical or health hazard to an employee. All hazardous chemicals used in the ACEPRD must be registered by the senior laboratory technologists and documented. All chemical inventories should be checked at least annually. Solutions for projects that are no longer active should be disposed of at the end of the project or at the end of each semester.

11.5 Transportation of Chemicals

Secondary containment of chemicals is required when transporting bottles of chemicals outside the laboratory. Secondary containment is a durable container (e.g. “Rubber Maid” tote, plastic pail or bottle carrier) capable of containing the contents of the original container in the event of a spill. Secondary containers should be used when chemicals are carried through corridors, stairways and inside elevators. Under no circumstances should anyone transport chemical w i t h o u t the use of secondary containers. Only carts with side rails should be used to transport chemicals. Do not carry specimen Dewars or covered, polystyrene boxes with dry ice or cryogenic liquid in a private vehicle. Be aware that strict federal and state regulations address the transport of hazardous (biological,

Chemicals, radiological) materials on public roads.

11.6 Chemical Waste

Most of the waste chemicals resulting from laboratory experiments are hazardous and their generation, storage and disposal must be given consideration in every experiment. Each laboratory must follow the procedures specified in the Hazardous Waste Management Plan, for proper disposal of hazardous waste.

11.7 Special Handling for Chemicals

- Label all chemical solutions including the name of all chemical components and each concentration;
- Never pour chemicals back into the reagent bottle. If you pour too much chemical out of its bottle, dispose of the extra chemical properly;
- Use the minimum amount of a particular chemical when possible;
- Always pour acids into water – NEVER the reverse to avoid a splatter reaction;
- Never mix acids and solvents – an explosive reaction can results.

11.8 Flammable Liquids

Fire hazards are associated with vapors from the flammable liquid. There have been many serious injuries and fatalities due to flammable liquid explosions caused by static electricity. To work safely with flammable liquids:

- Order only the amounts that are necessary;
- Work with flammable liquids inside a chemical fume hood. At the end of the day, return all flammable liquids to an approved flammable storage cabinet;
- Remove all nearby sources of ignition;
- Heat flammable liquids with safe heating equipment (e.g. mantles) or explosion safe equipment;
- When transferring flammable liquids using metal containers, bond and ground both containers. Avoid the use of plastic containers which require special grounding techniques;
- Store flammable liquids in UL-approved safety cans, flammable storage cabinets or flammable storage refrigerators;
- Locate all distillation apparatus inside the fume hood;
- Do not leave solvent distillation processes unattended.

11.8.1 Storage of Flammable Liquids

Limits for the storage of flammable solvents are based on fire hazards associated with each liquid. The following requirements must be followed:

- Flammable liquids stored in the laboratory should be kept to a minimum;
- Flammable liquids should not be stored next to incompatible chemicals. Segregate flammables from oxidizers and oxidizing acids (see Section 11.2);
- Storage of flammable liquids outside approved flammable storage cabinets is prohibited;
- Safety cans must not exceed 10 gallons per 100 square feet of laboratory space, including waste;
- If you have flammable storage cabinets and approved safety cans, storage must not exceed 20 gallons per 100 square feet of laboratory space;
- The purchase of 5 gallon containers of flammable liquids is strongly discouraged; All transfers of flammable liquids from containers of 5 gallons or more must be made inside a fume hood. These containers also must be kept in a flammable storage cabinet.

11.8.2 Safety Cans

Safety cans are approved by Underwriter Laboratory (UL) or Factory Mutual (FM) for flammable and (non-corrosive) combustible materials. They are made of 22-gauge steel and have a self- closing lid or quarter turn spigot.

11.8.3 Flammable Storage Cabinets

Flammable storage cabinets are designed to contain a fire for 10 minutes, enough time to allow you to escape. According to the National Fire Protection Association, flammable storage cabinets are not required to be ventilated. If there are ventilation openings in the cabinet, then: (1) The ventilation opening must be sealed with materials providing fire protection at least equivalent to that of the construction of the cabinet; or, (2) The cabinet must be vented outdoors using appropriate fire protection piping. Flammable storage cabinets should not be vented by removing bung caps. Follow these procedures when using or considering the use of flammable storage cabinets:

- Flammable storage cabinets should not be located near exits, electrical panels or sources of heat or ignition;
- Flammable storage cabinets must be listed by Factory Mutual, Underwriter's Laboratory or other qualified testing agencies;

- The flammable storage cabinet must be clearly labelled with a sign which reads: "Flammable – Keep Fire Away";
- Acids should not be stored in a flammable storage cabinet due to possible corrosion of the cabinet and incompatibility with organic solvents.

11.8.4 Flammable Storage Refrigerators

Flammable liquids should not be stored in an ordinary household-type refrigerator. Flammable storage refrigerators are specially designed to prevent internal ignition of flammable vapors coming in contact with ignition sources (e.g. the temperature control switch or the light). An updated log of the chemicals stored in the refrigerator should be kept in the lab, preferably in a plastic pocket attached to the door.

Important: Food and beverages must never be stored in any laboratory refrigerator in which chemicals, biological and radioactive materials are kept. If the food and beverage items are being used for research purposes, they must be labelled "Not for Human Consumption."

11.9 Corrosive Chemicals

Corrosive chemicals include strong acids and bases, dehydrating agents, nonmetal chlorides and halogens. These chemicals are acute health hazards and present problems in handling and storage. In addition to general procedures for handling of chemicals detailed in this manual, the following procedures should be followed:

- Purchase corrosives in containers coated with a protective plastic film, when available.
- Store corrosives under the hood, on low shelving or in storage cabinets. Gas cylinders (lecture size) should not be stored in the same cabinet with corrosive liquid, because of possible cylinder/valve damage. Properly segregate hazardous materials to prevent fire, explosion or toxic gas release.

11.9.1 Nitric Acid

Nitric Acid is both a strong acid and a strong oxidizer. Concentrations above 90% nitric acid are called fuming nitric acid, which is extremely toxic, corrosive, and reactive with combustible materials. Nitric acid reacts vigorously and violently with:

- Combustibles (glacial acetic acid, diesel fuel);
- Flammables (including flammable organic solvents--acetone, ether, and toluene);
- Bases (ammonium hydroxide, potassium hydroxide, sodium hydroxide);
- Reducing Agents (metal hydrides, ammonia, and phosphorus);

- Metals (lead, zinc (galvanized steel) aluminium;
- Metal Compounds (as an etchant; steel, metal alloys).

Handling: When handling high concentrations or large quantities wear butyl rubber or neoprene gloves, chemical splash goggles, face shield and impervious apron. When diluting nitric acid, add the acid to water, slowly. Always use a fume hood and clear the hood of flammable materials. Make sure the hood ductwork is not "ganged" to other hoods where organic solvents or ammonia might be used. The hood must be washed down after each use or at the end of the work day.

Storage: Store nitric acid in the original container. Dilute solutions must be stored in acid-resistant bottles. DO NOT STORE NITRIC ACID near materials with which it might react. If at all possible, store nitric acid in its own storage cabinet near floor level, it that is not possible, you may store nitric acid with inorganic acids as long as it is segregated from the other acids in a secondary container such as a plastic dish tub.

Spills: Small spills (<10 ml concentrated acid or 100 ml dilute acid), can be neutralized by gently adding soda ash or sodium bicarbonate and rinsing with copious quantities of acid. For large spills, evacuate the laboratory, close the doors and call 911. Stay near the scene to provide information to the emergency responders.

11.9.2 Hydrofluoric Acid

The use of hydrofluoric acid is strongly discouraged at the University of Jos. The ACEPRD Advisory Committee must first be consulted to ensure proper safety measures are in place, prior to start of experimental work or study.

Hydrofluoric acid (HF) has a number of physical, chemical, and toxicological properties that make it especially hazardous to handle. Both anhydrous hydrofluoric acid and aqueous solutions are clear, colorless, and highly corrosive liquids. When exposed to air, anhydrous HF and concentrated solutions produce pungent fumes, which are also dangerous. HF shares the corrosive properties common to mineral acids, but possesses the unique ability to cause deep tissue damage and systemic toxicity.

Prevention of exposure or injury must be the primary goal when working with HF.

Before any researcher uses HF, they should do the following:

- Read an MSDS for HF;
- Create a Standard Operating Procedure (SOP) for the process in which HF is used, incorporating information contained in Harvard guidelines;

- Obtain approval from the ACEPRD Advisory Committee;
- All work with HF must be done in the polypropylene vertical laminar flow wet process fume hood, which will be provided by the University authorities.

11.10 Compressed Gases

Compressed gases may present both physical and health hazards. Gases may be flammable, reactive, corrosive, or toxic and these properties must be considered when developing experimental procedures and designing apparatus. In addition, compressed gases, when not handled properly or not contained in properly designed vessels, can be extremely hazardous with a high potential for explosion. All procedures and experimental apparatus used in the handling of extremely toxic gases and gases with a high potential for explosion should be approved by the ESO prior to implementation. Although each approved gas cylinder is designed, constructed, and tested to safely contain its contents, the following procedures should be followed in handling and storing of compressed gases.

Procedures for Proper Handling of Gas Cylinders:

- In general, only keep cylinders in your lab that are in current use or waiting for immediate use;
- As a rule, there should be no more than two flammable gas and/or oxygen cylinders per lab and no more than one liquefied flammable gas (acetylene) cylinder per lab.
- Cylinders must be clearly marked with their contents;
- Regulators must be compatible with gas cylinders. Do not use adapters;
- Cylinders must be secured to a wall or bench. A gas cylinder cart or stand with a tight-fitting chain is also acceptable. This applies to all cylinders;
- Cylinders must be stored in a cool, dry and well-ventilated area away from ignition sources, electrical supply sources and heat;
- Cylinders must not be kept in corridors, hallways, stairways or cold rooms (or any other area with limited ventilation);
- A safety cap or regulator must always be attached to the cylinder;
- Transport capped cylinders on an approved cylinder cart with chain at all times.

NEVER TRANSPORT A CYLINDER WITH THE REGULATOR ATTACHED TO THE CYLINDER.

- Be familiar with the special hazards associated with compressed gases or cryogenic liquefied gases in use;
- Store full cylinders away from empty cylinders;
- Store oxidizers away from flammable gases;
- Do not store cylinders with acids and/or bases;
- Keep flammable gases away from doorways;
- Work with particularly hazardous gases with special procedures and in approved gas storage cabinets.

11.11 Cryogenic Fluids

Cryogenic liquids, such as liquid nitrogen, must be handled only in containers designed for that purpose. Full-face protection, including goggles and a face shield, as well as insulated gloves, must be worn when handling cryogenic liquids. When transferring liquid from one container to another, the receiving container must be cooled gradually.

11.12 Particularly Hazardous Chemicals

11.12.1 Highly Reactive Chemicals

Highly reactive chemicals are inherently unstable and can react in an uncontrolled manner to liberate heat, toxic gases or explosion. These include shock sensitive chemicals, high-energy oxidizers and peroxide formers. Before working with these materials, safety information should be reviewed to evaluate proper storage and handling procedures. In addition to the general procedures above, the following procedures are recommended:

- Secure reaction equipment properly;
- Use impact protection (shields and guards) in addition to chemical splash protection (i.e. eye protection, face shields, gloves, and laboratory coats);
- Handle shock-sensitive chemicals gently to avoid friction, grinding and impact;
- Dispose of reagents with suspect purity and age.

NOTE: The ACEPRD is not currently equipped to handle experiments with highly reactive chemicals which require an isolated facility with explosion venting and explosion- resistant construction.

11.12.2 Peroxide-Forming Compounds

Peroxide-forming chemicals are a class of compounds that have the ability to form shock-sensitive explosive peroxide crystals. A peroxide is a chemical that contains a peroxo (O-O) unit, one that has the chemical formula of O_2 (diethyl ether and tetrahydrofuran are two of the more common peroxide-forming chemicals). A more complete list of peroxide forming chemicals is included in Appendix F. Under normal storage conditions, peroxides have the potential to generate and accumulate peroxide crystal formations, which may violently detonate when subjected to thermal or mechanical shock. Peroxide-forming chemicals react with oxygen—even at low concentrations-to form peroxy compounds. The risk associated with peroxide formation increases if the peroxide crystallizes or becomes concentrated by evaporation or distillation. Factors that affect the rate of peroxide formation include exposure to air, light and heat, moisture, and contamination from metals.

Peroxide crystals may form on the container plug or the threads of the lid and detonate when the lid is twisted. Do not open a liquid organic peroxide or peroxide-forming chemical if crystals or a precipitate are present. It is extremely important that the following procedures be followed regarding the identification, handling, storage, and disposal of peroxide-forming chemicals:

- When possible, purchase only peroxide-forming chemicals which contain a peroxide formation inhibitor (e.g., tetrahydrofuran or diethyl ether inhibited with butylated hydroxytoluene (BHT) or borane;
- Only purchase quantities of peroxide-forming chemicals that you expect to use with expiration and disposal time frames;
- All bottles of peroxide-forming chemicals must have the **date received** marked on the container;
- When the bottle is first opened, the container must be marked with the **date opened**;
- Do not store peroxide-forming materials in clear glass bottles (light can accelerate the chemical reactions that form peroxides). Always use an amber, but transparent bottle. Do not store the material in a metal can or other container that prevents you from examining the contents without having to open or touch the container;
- Do not store peroxide-forming chemicals near heat, sunlight or ignition sources. Avoid places that undergo temperature variations which can cause the bottle to "breathe in" oxygen;

- An explosion proof refrigerator must be used if the peroxide-forming chemical is flammable and requires refrigeration;
- Do not distil, evaporate, or concentrate a peroxide-forming chemical until you have first tested it for the presence of peroxides;
- Never under any circumstances touch or attempt to open a container of a peroxide-forming liquid if there are whitish crystals around the cap and/or in the bottle. The friction of screwing the cap may detonate the bottle. If you encounter such a bottle, contact the ESO office immediately for removal. DO NOT TOUCH OR MOVE THE SUSPECT BOTTLE YOURSELF FOR ANY REASON**!**

11.12.3 Chemicals of High Acute and Chronic Toxicity

Certain chemicals have been identified as causing acute health effects or long-term chronic health effects. Substances of high acute toxicity cause immediate health effects at very low concentrations (moderately toxic LD50[7] of 500-5,000 mg/kg; very toxic LD50 of 50 500 mg/kg, extremely toxic LD50 of 5-50mg/kg and supertoxic LD50 <5mg/kg). Some examples of chemicals with high acute toxicity are hydrogen cyanide, phosgene or arsine. Research with hazardous chemicals with ACGIH TLV-TWA value or ceiling value < 10 ppm should receive prior approval from the ACEPRD Advisory Committee. Substances that have high chronic toxicity cause damage after repeated exposure over a period of time. These may include carcinogens such as benzene, reproductive toxins, mutagens, teratogens and sensitizers. Laboratory workers (male and female) of childbearing age should be notified of any reproductive toxins being used in the laboratory. Any employee who is pregnant or planning to become pregnant should contact her personal physician or a health physician at the University Clinic to assess potential exposures.

Procedures for Handling Highly Toxic Chemicals

Because chemicals with high acute toxicity and those with high chronic toxicity are hazardous at very low concentrations, the following practices must be observed:

- Notify all lab workers of the particular hazards associated with this work;
- Minimize contact with these chemicals by any route of exposure (inhalation, skin contact, mucous membrane contact, or injection);
- Work only in a properly operating chemical fume hood or glove box;
- Remove all protective clothing before leaving the area and decontaminate it or if disposable, place it in a plastic bag and secure it. Contact the ESO for disposal;

- Review emergency procedures specific to these chemicals prior to each operation;
- Decontaminate work surfaces after completing procedure;
- Do not conduct normal laboratory work in the designated area until decontaminated.

Ethidium Bromide

Ethidium Bromide (EtBr) is commonly used in the biological laboratory as a non-radioactive marker for identifying and visualizing nucleic acid bands in electrophoresis and in other methods of gel-based nucleic acid separation. EtBr is a dark red, crystalline, non-volatile solid, moderately soluble in water, which fluoresces readily with a reddish-brown color when exposedto ultraviolet light (UV). Its formula is 2,7-Diamino-10-ethyl-9-phenyl-phenanthridium bromide, CAS# 1239-45-8. Although it is an effective tool, its hazardous properties require special safe handling and disposal procedures. EtBr is a potent mutagen and is moderately toxic after an acute exposure. EtBr can be absorbed through skin, so it is important to avoid any direct contact with the chemical. EtBr is also an irritant to the skin, eyes, mouth and upper respiratory tract. It should be stored away from strong oxidizing agents in a cool, dry place and the container must be kept undamaged and tightly closed. Individuals using EtBr should follow these safety procedures:

- EtBr users should receive documented safety training on its hazards;
- EtBr must appear on the laboratory's chemical inventory, with accurate estimates of on-hand quantities;
- Pure EtBr should only be handled in a fume hood, with the user wearing protective equipment that includes a lab coat, closed-toe shoes, chemically resistant gloves and chemical safety goggles (not just safety glasses).

Dimethyl Mercury

Dimethyl mercury belongs to a class of organic mercury compounds known as alkyl mercuries. It is used primarily in research. It is a colorless liquid described as having a weak, sweet odor. Dimethyl mercury is readily absorbed through the skin. A severely toxic dose requires the absorption of less than 0.1mL. Many materials, including several plastics and rubber compounds, have also been shown to be permeable to this chemical. It is highly reactive and flammable. Because of its high vapor pressure (50-82 mm Hg at 20°C), the inhalation route of entry is also significant.

University of Jos faculty and students are not permitted to work with dimethyl mercury. If any faculty desires to change this policy, the Centre of Excellence (ACEPRD) advisory

committee must first be consulted to ensure proper safety measures are in place, prior to the start of experimental work or study.

12 BIOLOGICAL SAFETY

A biohazard is defined as "an agent of biological origin that has the capacity to produce deleterious effects on humans, i.e., microorganisms, toxins and allergens derived from those organisms; and allergens and toxins derived from higher plants and animals." The following guidelines address the safe handling and containment of infectious microorganisms and hazardous biological materials. More detailed information can be found in "*Biosafety in Microbiological and Biomedical Laboratories*" ' University of Jos lab personnel typically do not conduct research involving bio-hazardous material. Therefore, if a researcher proposes to conduct any work with bio-hazardous materials, one copy of a plan describing the proposed work, risk assessment, and associated safety protocols must be submitted to the ACEPRD Advisory Committee for pre-approval.

As stated in on page 4 of the BMBL Introduction:

> *The primary risk criteria used to define the four ascending levels of containment, referred to as biosafety levels 1 through 4, are infectivity, severity of disease, transmissibility, and the nature of the work being conducted. Another important risk factor for agents that cause moderate to severe disease is the origin of the agent, whether indigenous or exotic. Each level of containment describes the microbiological practices, safety equipment and facility safeguards for the corresponding level of risk associated with handling a particular agent. The basic practices and equipment are appropriate for protocols common to most research and clinical laboratories. The facility safeguards help protect non-laboratory occupants of the building and the public health and environment.*
>
> *Biosafety level 1 (BSL-1) is the basic level of protection and is appropriate for agents that are not known to cause disease in normal, healthy humans. Biosafety level 2 (BSL-2) is appropriate for handling moderate-risk agents that cause human disease of varying severity by ingestion or through percutaneous or mucous membrane exposure. Biosafety level 3 (BSL-3) is appropriate for agents with a known potential for aerosol transmission, for agents that may cause serious and potentially lethal infections and that are indigenous or exotic in origin. Exotic agents that pose a high individual*

risk of life-threatening disease by infectious aerosols and for which no treatment is available are restricted to high containment laboratories that meet biosafety level 4 (BSL-4) standards.

It is important to emphasize that the causative incident for most laboratory-associated infections (LAIs) is unknown. Less obvious exposures such as the inhalation of infectious aerosols or direct contact of the broken skin or mucous membranes with droplets containing an infectious microorganism or surfaces contaminated by droplets may possibly explain the incident responsible for a number of LAIs. Most manipulations of liquid suspensions of microorganisms produce aerosols and droplets. Small-particle aerosols have reparable size particles that may contain one or several microorganisms. These small particles stay airborne and easily disperse throughout the laboratory. When inhaled, the human lung will retain those particles. Larger particle droplets rapidly fall out of the air, contaminating gloves, the immediate work area, and the mucous membranes of unprotected workers. A procedure's potential to release microorganisms into the air as aerosols and droplets is the most important operational risk factor that supports the need for containment equipment and facility safeguards.

The Center for Disease Control's (CDC) recommended biosafety levels (BSLs) are as follows:

BSL	Pathogenic Agents	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
1	Not known to consistently cause disease in healthy adults	Standard Microbiological Practices	None required	Open bench top sink required
2	Associated with human disease (hazard = skin injury, ingestion, mucous membrane exposure)	BSL-1 practice plus: Limited access Biohazard warning signs "Sharps" precautions Biosafety manual defining waste decontamination or medical surveillance practices	Class I or II Biosafety Cabinets (BCSs) for agents that cause splashes or aerosols of infectious materials PPE (lab coats, gloves, face protection)	BSL-1 plus Autoclave available
3	Indigenous or exotic agents with potential for aerosol transmission (disease may have serious or lethal consequences)	BSL-2 practice plus: Controlled access Decontamination of all waste Decontamination of lab clothing before laundering Baseline serum	Class I or II BCSs for all open manipulations of agents PPE (protective lab clothing, gloves, respiratory protection as required)	BSL-2 plus Physical separation from access corridors Self-closing, double-door access Exhausted air not re-circulated Negative airflow into laboratory
4	Dangerous/exotic agents which pose high risk of life-threatening disease, aerosol-transmitted lab infections or related agents with unknown risk of transmission	BSL-3 practices plus: Clothing change before entering Shower on exit All material decontaminated on exit from facility	All procedures conducted in Class III BSCs or Class I or II BSCs in combination with full-body, air-supplied, positive pressure personnel suit	BSL-3 plus Separate building or isolated zone Dedicated supply and exhaust, vacuum, and decontamination systems Other requirements as needed

Source: CDC: "Biosafety in the Microbiological and Biomedical Laboratories", 5th Edition.

12.1 General Biosafety Procedures

As discussed in detail in the following sections, University of Jos requires consultation before work involving infectious agents are used e.g., Biological Safety Level (BSL)- 2 or higher BSL level organisms. Nonetheless, biological materials at the BSL-1 level still must be handled with care, appropriate PPE must be worn (gloves, lab coats, and safety glasses at the minimum) and waste must be disposed of properly to protect human health and the environment, as outlined in Section 13. At a minimum, the following safety practices should be followed:

- Treat all microorganisms as potential pathogens;
- Sterilize equipment and materials;
- Disinfect work areas before and after use;
- Wash your hands and wear gloves for extra protection;
- Never pipette by mouth;

- Do not eat or drink in the lab and do not store food in areas where microorganisms are stored;
- Label everything clearly—include the date, the organism's name (if relevant), and the name of instructor responsible for the work/student;
- Autoclave and disinfect all waste material;
- Clean up spills with care (see Section 9.5);
- Dispose of hypodermic needles in the sharps container without recapping to avoid accidental punctures;
- Use plastic pipettes instead of glass when possible;
- Use puncture-resistant sharps containers and glass-only boxes for the disposal of hypodermic needles and syringes, razor blades and other sharp items--**do not use cardboard containers for hypodermic needles** (see Section 6.4.8);
- Labels should be used to indicate the presence of biological materials in storage, but NOT on waste bags. A biological hazard sign with the international biological warning symbol should be affixed to the doors of all biological laboratories as a precautionary measure.

12.2 Risk Assessment

It is the responsibility of the Environmental Safeguards Officer, in conjunction with the ACEPRD Advisory Committee, to conduct a risk assessment to determine the proper work practices and containment requirements to work with bio-hazardous material. The risk assessment should identify features of micro-organisms as well as host and environmental factors that influence the potential for workers to have a biohazard exposure and to determine the appropriate BSL level. When performing a risk assessment, it is advisable to take a conservative approach if there is incomplete information available. Factors to be considered in evaluating risk include:

- Pathogenicity: The more severe the potentially acquired disease, the higher the risk;
- Route of transmission: the greater the aerosol potential, the higher the risk of infection;
- Stability: The longer the agent can survive in the environment, the greater the risk;
- Infectious dose: An individual's immune system should also be considered;
- Concentration: The higher the concentration, the greater the risk;
- Origin: Geographic location, host agent, and nature of the source;
- Animal study Data: Use caution when translating infectivity rate data from one species to another.

- Availability of effective prophylaxis or therapeutic intervention, such as effective vaccines.
- Medical surveillance: Annual physicals, health monitoring, etc.
- Experience and skill level of at-risk personnel.

12.2.1 Biosafety Level 1

Biosafety Level 1 (BSL-1)) is suitable for work involving well characterized agents not known to consistently cause disease in normal healthy adult humans and present minimal potential hazard to laboratory personnel and the environment. BSL-1 laboratories are not necessarily separated from the general traffic patterns in the building. Work is typically conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required, but may be used as determined by appropriate risk assessment.

Laboratory personnel must have specific training in the procedures conducted in the laboratory and must be supervised by a scientist with training in microbiology or a related science, regarding:

- Specific job duties;
- Necessary precautions to prevent exposures;
- Exposure evaluation procedures;
- Annual updates (or additional training) when procedural or policy changes occur;
- All laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify for appropriate counselling and guidance.

Standard microbiological practices for BSL-1 include:

- The laboratory supervisor must enforce access policies for the laboratory;
- Personnel must wash their hands after working with potentially hazardous materials and before leaving the laboratory;
- No eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose;
- Mouth pipetting is prohibited; mechanical pipetting devices must be used;

- Policies for safe handling of sharps (including needles, scalpels, pipettes, and broken glassware) must be adhered to (see Section 6.4.8). Whenever possible, adopt improved engineering and work practice controls that reduce risk of sharps injuries, such as:
- Needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal;
- Used needles and syringes must be carefully placed in puncture-resistant containers used for sharps disposal (e.g., coffee can, heavy duty plastic container such as a laundry detergent bottle;
- Non-disposable sharps must be placed in a hard walled container for transport to a decontamination processing area, preferably by autoclaving;
- Broken glassware must not be handled directly. Use a brush and dustpan, tongs, or forceps;
- Use plastic instead of glass whenever possible;
- Perform all procedures to minimize the creation of splashes and/or aerosols;
- Decontaminate work surfaces after completion of work and after and spill or splash of potentially infectious material;
- Decontaminate all cultures, stocks, and other potentially infectious materials before disposal, or package them in accordance with applicable regulations. Contact the ESO for assistance with disposal;
- A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present (see Section 6.5.1);
- Laboratories must have a sink for hand-washing;
- An effective integrated pest management program is required.

12.2.2 Biosafety Level 2

Biosafety Level 2 builds upon BSL-1. BSL-2 is suitable for work involving agents that pose moderate hazards to personnel and the environment. If differs from BSL-1 in that:

- Laboratory personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures;
- Access to the laboratory is restricted when work is being conducted;

- All procedures in which infectious aerosols or splashes may be created are conducted in Biological Safety Cabinets (BSCs) or other physical containment equipment;
- In addition to the BSL-1 practices listed in Section 8.4. The additional practices listed below must also be followed for BSL-2:
- All persons entering the laboratory must be advised of the potential hazards and meet specific entry/exit requirements;
- Laboratory personnel must be provided with medical surveillance, as appropriate, and offered available immunizations for agents handled or potentially present in the laboratory;
- Collection and storage of serum samples from at-risk personnel should be considered;
- A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible;
- The laboratory supervisor must ensure that laboratory personnel demonstrate proficiency in standard and special microbiological practices before working with BSL-2 agents;
- Potentially infectious materials must be placed in a durable, leak proof container during collection, handling, processing, storage, or transport with a facility;
- Laboratory equipment should be routinely decontaminated, as well as after spills, splashes, or other potential decontamination;
- Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped to work with infectious material;
- Equipment must be decontaminated before repair, maintenance, or removal from the laboratory;
- Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the laboratory biosafety manual. All such incidents must be reported to the laboratory technologist and ESO. Medical evaluation, surveillance, and treatment should be provided and appropriate records maintained;
- Animals and plants not associated with the work being performed must not be permitted in the laboratory;
- All procedures involving the manipulation of infectious materials that may generate an aerosol should be conducted with a BSC or other physical containment device.

The following primary barriers and personal protective equipment (PPE) must be used for BSL-2 activities:

- Properly maintained BSCs, appropriate PPE, or other physical containment devices must be used whenever:
- Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include pipetting, centrifuging, grinding, blending, shaking, mixing, sonicating, opening containers of infectious materials, inoculation of animals intra-nasally, and harvesting infected tissues from animals or eggs;
- High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory use sealed rotor heads or centrifuge safety cups;
- Protective lab coats, gowns, smocks, or uniforms designated for laboratory use must be worn while working with hazardous materials. Remove protective clothing before leaving for non-laboratory areas. Dispose of protective clothing appropriately;
- Eye and face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials when the microorganisms must be handled outside the BSC or containment device. Eye and face protection must be disposed of with other contaminated laboratory waste or decontaminated before reuse. Persons who wear contact lenses in laboratories must also wear eye protection;
- Gloves must be worn to protect hands from exposure to hazardous materials (see section 7.3);
- Gloves must not be worn outside the laboratory. BSL-2 laboratory workers should:

  - Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
  - Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory. Hand washing protocols must be rigorously followed.
  - Do not wash or re-use disposable gloves.
  - Eye, face and respiratory protection should be used in rooms containing infected organisms as determined by the risk assessment.

Secondary barriers in BSL-2 laboratories include:

- Laboratory doors should be self-closing and have locks;
- Laboratories must have a sink for hand washing. The sink may be manually, hands-free, or automatically operated. It should be located near the exit door;
- The laboratory should be designed so that it can be easily cleaned and decontaminated;
- Carpets and rugs in laboratories are not permitted. Spaces between benches, cabinets, and equipment should be accessible for cleaning;
- Laboratory furniture must be capable of supporting anticipated loads and uses. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals. Chairs must be covered with a non-porous material than can be easily cleaned and decontaminated with appropriate disinfectant;
- Laboratory windows that open to the exterior are not recommended, but if they exist they must be fitted with screens;
- BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, windows that can be opened, heavily travelled laboratory areas, and other possible airflow disruptions;
- Vacuum lines should be protected with liquid disinfectant traps;
- An eyewash station must be readily available;
- There are no specific requirements for ventilation systems. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without recirculation to spaces outside of the laboratory;
- HEPA filtered exhaust air from a Class II BSC can be safely re-circulated back into the laboratory environment if the cabinet is tested and certified a least annually and operated according to manufacturer's recommendations. BSCs can also be connected to the laboratory exhaust system by either a thimble (canopy) connection or directly exhausted to the outside through a hard connection. Provisions to assure property safety cabinet performance and air system operation must be verified;
- A method for decontaminating all laboratory wastes should be available in the facility (e.g. autoclave, chemical disinfection, incineration, or other validated decontamination method).

12.3 Environmental Samples

Environmental samples, such as water, air, or earth, may potentially contain pathogens (i.e. bacteria, viruses, spores) that could present a health hazard to people, animals or the environment. Using appropriate personal protective equipment when collecting environmental samples will reduce exposure to potential pathogens. After working with environmental samples, good personal hygiene (i.e., hand washing before eating) is recommended to minimize exposure. If the environmental sample is known to be contaminated or if the environmental sample will be enhanced in the laboratory by culturing or other growing mechanisms, a more detailed evaluation of the process and PPE may be required, in order to ensure procedures meet the appropriate level of BSL-1 or BSL-2. Certain techniques used to enhance and/or culture environmental samples should be conducted at BSL-2 or higher levels in an appropriate containment device, such as a biological safety cabinet**.** If a microbe is identified and known to be pathogenic, its culture at the University of Jos is prohibited until a change in BSL status has been designated.

12.4 Pathogenic Microorganisms

University of Jos and ACEPRD work primarily with organisms that are well characterized and not known to consistently cause disease in healthy adult humans, and present minimal potential hazard to lab personnel or the environment. Thus, the appropriate safety level would be Biosafety Level (BSL)-1. Examples of agents that may be used in a BSL-1 laboratory include:

- *Bacillus subtilis.*
- *Saccharomyces cerevisiae.*
- *Escherichia coli* (non-pathogenic).
- Exempt organisms listed in the NIH Recombinant DNA Guidelines (See Section 12.7).

If a microbe is identified and known to be pathogenic, its culture at University of Jos and ACEPRD is prohibited until a change in BSL status had been designated. If any faculty desires to change this designation, the ACEPRD Advisory Committee must first be consulted to ensure proper safety measures are in place, prior to the start of experimental work or study. For further information on the various safety levels designated for microorganisms, and the safe work practices required at each level, consult the guidelines specified in Biosafety in Microbiological and Biomedical Laboratories (BMBL). http://www.cdc.gov/biosafety/publications/bmbl5/.

12.5 Laboratory Animals

University of Jos has an animal care facility for living warm-blooded animals as well as research and teaching using cold-blooded vertebrates and invertebrates. Therefore all animal care personnel must conduct their activities with utmost care to prevent infections and other diseases arising from contact with animals.

12.5.1 Vertebrates

Any use of vertebrate animals for teaching and research must first be reviewed and approved by the ACEPRD Advisory Committee University of Jos. This committee is responsible for ensuring the care, use and humane treatment of vertebrate animals used in research, testing, and instruction. This policy applies to **ALL** research, testing and instruction involving vertebrate animals, regardless of whether it is funded or not or whether it is conducted on-campus or off-campus.

The CDC has developed the following animal biosafety levels (ABSLs) for activities in which experimentally or naturally infected vertebrate animals are used. These levels are similar to the biosafety levels for microorganisms:

ABSL	Agent	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
	Not known to consistently cause disease in health human adults.	Standard animal care And management practices, including appropriate medical surveillance programs	As required for normal care of each species	Standard animal facility No recirculation of exhaust air. Directional air flow recommended
2	Associated with human disease. (hazard = skin exposure, ingestion, mucous membrane exposure)	ABSL-1 practices plus: Limited access Biohazard warning signs Sharps precautions Biosafety manual Decontamination of all infectious wastes and of animal cages prior to washing	ABSL-1 equipment plus Containment equipment appropriate for animal species PPE (lab coats, gloves, face and respiratory protection as needed	ABSL-1 facility plus Autoclave available Handwashing sink available in animal room Mechanical cage washer used
3	Indigenous or exotic agents with potential for aerosol transmission— disease may have serious health effects	ABLS-2 practices plus Controlled access Decontamination of clothing before laundering Cages decontaminated before bedding removed Disinfectant foot bath as needed	ABSL-2 equipment plus Containment equipment for housing animals and cage dumping activities Class I or II BSCs available for manipulative procedures that may create infectious aerosols Appropriate respiratory protection	ABSL-2 facility plus Physical separation from access corridors Self-closing, double-door access Sealed penetrations Sealed windows Autoclave available in facility
4	Dangerous/exotic agents that pose high risk of life threatening disease, aerosol transmission, or related agents with unknown risk of transmission	ABSL-3 practices plus Entrance through change room where personal clothing is removed and lab clothing is put on Shower on exiting All wastes decontaminated before removal from facility	ABSL-3 equipment plus Maximum containment equipment (i.e., Class III BSC or partial containment equipment in combination with full body, air-supplied positive-pressure personnel suit) used for all procedures and activities	ABSL-3 facility plus: Separate building or isolated zone Dedicated supply and exhaust, vacuum and decontamination systems Other equipment as needed.

Source: CDC: "Biosafety in the Microbiological and Biomedical Laboratories", 5th Edition

University of Jos works primarily with organisms that are well characterized and not known to consistently cause disease in immune-competent adult humans, and present minimal potential hazard to lab personnel or the environment. Thus the appropriate safety level would be

Animal Biosafety Level (ABSL)–1. If any faculty/researcher desires to change this designation, the ACEPRD Advisory Committee must first be consulted to ensure proper safety measures are in place, prior to the start of experimental work or study. All employees are expected to maintain acceptable health care and hygiene standards. Animal care personnel are required to wear lab coats, scrub suits, uniforms or other suitable attire in animal areas. Other protective clothing may be required in specific instances. Under no circumstances is eating, smoking, drinking, or application of cosmetics allowed in animal areas.

12.5.2 Arthropods

Arthropods (insects, arachnids, crustaceans, and others) are associated with potential risks should they escape because many are vectors of infectious human diseases. When they are experimentally infected with a human pathogen, the arthropods represent an immediate risk to those who come into contact with them. Even when they are uninfected, they can represent a risk to the community if, by escaping they become the crucial link completing the transmission cycle for a disease they vector.

As summarized below, the four arthropod containment levels (ACLs) add increasingly stringent measures similar to biosafety levels:

Arthropod Containment Level (ACL):	1	2	3	4
Arthropod distribution, escaped arthropod fate	A. Indigenous species, and, B. Inviable or transient exotic species. Incapable of transmitting active VDB cycling in the locale	A. Exotic species with establishment, B. Indigenous species, and C. Transgenic species		
Infection status	Uninfected or infected with non-pathogen	Up to BSL-2	Up to BSL-3	BSL-4
Practices	ACL-1 Standard Arthropod-Handling Practices	ACL-1 plus more rigorous disposal, signage, and limited access	ACL-2 with more highly restricted access, training, and record-keeping	ACL-3 with high access restriction, extensive training, full isolation
Primary Barriers	Species-appropriate containers	Species-appropriate containers	Escape-proof arthropod containers, glove boxes, BSC	Escape-proof arthropod containers handled in cabinet or suit laboratory
Secondary Barriers	None	Separated from labs, double doors, sealed electrical/plumbing openings;breeding containers/harborages minimized	BSL-3	BSL-4
Source: Arthropod Containment Levels (ACLs), Vector-Borne and Zoonotic Diseases (Volume 3, Number 2, 2003, Mary Ann Liebert, Inc.)				

Arthropod Containment Level 1 (ACL-1) is suitable for work with uninfected arthropod vectors or those infected with a non-pathogen. This includes indigenous species that are already present in the local geographic region regardless of whether there is active vector-borne disease (VBD) transmission in the locale. ACL-1 is also suitable for exotic species that upon escape would not be viable or become only temporarily established in areas not having active vector-borne disease transmission. This category includes most educational use of arthropods.

University of Jos works primarily with organisms that are well characterized and not known to consistently cause disease, and present minimal potential hazard to lab personnel or the environment. Thus, the appropriate safety level would be ACL-1. If any faculty/researcher

desires to change this designation, the ACEPRD Advisory Committee must first be consulted to ensure proper safety measures are in place, prior to the start of experimental work or study.

12.6 Genetically Modified Organisms GMO's

GMOs are organisms whose genetic material has been altered in a way that is not possible by reproduction or natural recombination. Techniques that lead to the formation of a GMO include:

- Recombinant-DNA- and RNA-techniques involving the use of host/vector systems;
- Techniques involving the direct introduction into a micro-organism of heritable material prepared outside the micro-organism, including microinjection, macro-injection and micro-encapsulation;
- Cell fusion or hybridisation techniques where living cells containing new combinations of heritable genetic material are formed through the fusion of two or more cells by means of methods that do not occur naturally.

The following techniques are not considered to result in genetic modification, on condition that they do not involve the use of recombinant-DNA molecules or genetically modified organisms:

- In-vitro fertilisation;
- Natural processes such as: conjugation, transduction, viral infection, transformation;
- Polyploidy induction.

Biotechnology and genetic engineering have been successfully used to construct "de novo" viable viruses (18), to enhance the desired properties of microorganisms for public health (diagnostics, vaccines), clinical applications (gene therapy, antimicrobials), agriculture (disease-resistant crops, vector control) and commercial purposes. These include increased quality and quantity of products, enhanced resistance against biological and chemical agents as well as adaptation to growth in hostile environmental conditions. These same technologies may also be employed to increase the virulence of pathogens, or used to modify the resistance of pathogens to existing prophylaxis and treatments. The transfer of genetic materials is commonly associated with methods that impart a preferential selective factor to identify the transgenic recipient. An example is the common selective factor for drug resistance. This drug resistance may under dual-use become a potent biological weapon. Consequently, GMOs are subject to specific oversight through the Convention on Biological Diversity (19) and its Cartagena Biosafety Protocol (20),

or the Biological and Toxin Weapons Convention (3), for their production, use and dissemination.

12.6.1 Risk Assessment

GMOs, like non-GMOs, are neither intrinsically hazardous, nor intrinsically safe. That is why risk assessment is performed on a case-by-case basis. The risk assessment procedure consists of three subsequent steps:

- Firstly, the characteristics of the host, vector and donor sequences that are potentially hazardous like pathogenicity, toxicity, the possibility of uncontrolled spreading of the organism or its genetic material, are identified. This leads to a preliminary identification, of the risk level;
- Secondly, the circumstances under which the organisms can be handled safely are determined, taking into account the following aspects:
  - The characteristics of the environment that could be exposed to the GMOs;
  - The type and scale of the activity;
  - Any non-standard activities or actions.
- Finally, a risk class is determined, based on the results of the first two steps.

As for pathogens, four risk classes have been determined for GMOs:

Risk Class 1	GMO activities holding no or a negligible risk	Activities for which level 1 containment is appropriate to protect human health as well as the environment
Risk Class 2	GMO activities holding a low risk	Activities for which level 2 containment is appropriate to protect human health as well as the environment
Risk Class 3	GMO activities holding a moderate risk	Activities for which level 3 containment is appropriate to protect human health as well as the environment
Risk Class 4	GMO activities holding a high risk	Activities for which level 4 containment is appropriate to protect human health as well as the environment

12.7 Recombinant DNA

University of Jos faculty, and students are required to consult the ACEPRD Advisory Committee on any work involving Recombinant or Synthetic Nucleic Acid Molecules or GMO's unless the experimental materials are defined as exempt by the National Institutes of Health Guidelines Involving Recombinant or Synthetic Nucleic Acid Molecules. This is to ensure that proper safety measures are in place, prior to the start of experimental work or study. The following excerpts are provided to assist researchers in determining if their experiments meet the requirements for exemption.

From Section I-B:

In the context of the NIH Guidelines, recombinant and synthetic nucleic acids are defined as:

i. molecules that a) are constructed by joining nucleic acid molecules and b) that can replicate in a living cell, i.e., recombinant nucleic acids;

ii. nucleic acid molecules that are chemically or by other means synthesized or amplified, including those that are chemically or otherwise modified but can base pair with naturally occurring nucleic acid molecules, i.e., synthetic nucleic acids or

iii. molecules that result from the replication of those described in (i) or (ii) above.

From Section III-F:

The following recombinant or synthetic nucleic acid molecules are exempt from the NIH Guidelines and registration with the Institutional Biosafety Committee is not required; however, other federal and state standards of biosafety may still apply to such research (for example, the Centers for Disease Control and Prevention (CDC)/NIH publication Biosafety in Microbiological and Biomedical Laboratories).

Those synthetic nucleic acids that:

1. Can neither replicate nor generate nucleic acids that can replicate in any living cell (e.g., oligonucleotides or other synthetic nucleic acids that do not contain an origin of replication or contain elements known to interact with either DNA or RNA polymerase;
2. Are not designed to integrate into DNA;
3. Do not produce a toxin that is lethal for vertebrates at an LD50 of less than 100 nanograms per kilogram body weight. If a synthetic nucleic acid is deliberately transferred into one or more human research participants and meets the criteria of Section III-C, it is not exempt under this Section;

4. Those that are not in organisms, cells, or viruses and that have not been modified or manipulated (e.g., encapsulated into synthetic or natural vehicles) to render them capable of penetrating cellular membranes;
5. Those that consist solely of the exact recombinant or synthetic nucleic acid sequence from a single source that exists contemporaneously in nature;
6. Those that consist entirely of nucleic acids from a prokaryotic host, including its indigenous plasmids or viruses when propagated only in that host (or a closely related strain of the same species), or when transferred to another host by well-established physiological means;
7. Those that consist entirely of nucleic acids from a eukaryotic host including its chloroplasts, mitochondria, or plasmids (but excluding viruses) when propagated only in that host (or a closely related strain of the same species);
8. Those that consist entirely of DNA segments from different species that exchange DNA by known physiological processes, though one or more of the segments may be a synthetic equivalent. A list of such exchangers will be prepared and periodically revised by the NIH Director with advice of the RAC after appropriate notice and opportunity for public comment;
9. Those genomic DNA molecules that have acquired a transposable element provided the transposable element does not contain any recombinant and/or synthetic DNA;
10. Those that do not present a significant risk to health or the environment (see Section IV-C-1-b-(1)-(c), Major Actions), as determined by the NIH Director, with the advice of the RAC, and following appropriate notice and opportunity for public comment. See Appendix C, Exemptions under Section III-F-8 for other classes of experiments which are exempt from the NIH Guidelines.

Appendix B-I. Risk Group 1 (RG1) Agents

RG1 agents are defined as those not associated with disease in healthy adult humans. Examples of RG1 agents include but are not limited to:

- Asporogenic Bacillus subtilis or Bacillus licheniformis (see Appendix C-IV-A, Bacillus subtilis or Bacillus licheniformis Host-Vector Systems, Exceptions);
- adeno- associated virus (AAV – all serotypes); and recombinant or synthetic AAV constructs, in which the transgene does not encode either a potentially tumorigenic gene product or a toxin molecule and are produced in the absence of a helper virus;
- Escherichia coli (see Appendix C-II-A, Escherichia coli K-12 Host Vector;

- Systems, Exceptions) is an RG1 agent if it (1) does not possess a complete;
- lipopolysaccharide (i.e., lacks the O antigen); and (2) does not carry any active virulence factor (e.g., toxins) or colonization factors and does not carry any genes encoding these factors. Page 40 - NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (March 2013).

Appendix C-II. Escherichia coli K-12 **Host-Vector Systems**

Experiments which use Escherichia coli K-12 host-vector systems, with the exception of those experiments listed in Appendix C-II-A, are exempt from the NIH Guidelines provided that:

- the Escherichia coli host does not contain conjugation proficient plasmids or generalized transducing phages;
- lambda or lambdoid or Ff bacteriophages or non-conjugative plasmids (see Appendix C-VIII-B, Footnotes and References of Appendix C) shall be used as vectors.

However, experiments involving the insertion into Escherichia coli K-12 of DNA from Page 47 - NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (March 2013), Footnotes and References of Appendix C) with Escherichia coli may be performed with any Escherichia coli K-12 vector (e.g., conjugative plasmid). When a non-conjugative vector is used, the Escherichia coli K-12 host may contain conjugation-proficient plasmids either autonomous or integrated, or generalized transducing phages. For these exempt laboratory experiments, Biosafety Level (BL) 1 physical containment conditions are recommended. For large-scale fermentation experiments, the appropriate physical containment conditions need be no greater than those for the host organism unmodified by recombinant or synthetic nucleic acid molecule techniques; the Institutional Biosafety Committee can specify higher containment if deemed necessary.

Appendix C-II-A. Exceptions

The following categories are **not exempt** from the NIH Guidelines:

I. experiments described in Section III-B which require NIH/OBA and Institutional Biosafety Committee approval before initiation;

II. experiments involving DNA from Risk Groups 3, 4, or restricted organisms (see Appendix B, Classification of Human Etiologic Agents on the Basis of Hazard, and Sections V-G and V-L, Footnotes and References of Sections I through IV) or cells known to be infected with these agents may be conducted under containment

conditions specified in Section III-D-2 with prior Institutional Biosafety Committee review and approval;

III. large-scale experiments (e.g., more than 10 liters of culture), and

IV. experiments involving the cloning of toxin molecule genes coding for the biosynthesis of molecules toxic for vertebrates (see Appendix F, Containment Conditions for Cloning of Genes Coding for the Biosynthesis of Molecules Toxic for Vertebrates).

12.8 Select Agents and Toxins

The *Public Health Security and Bioterrorism Preparedness and Response Act of 2002* requires the Department of Health and Human Services (DHHS) to regulate the possession, use, and transfer of biological agents or toxins (i.e., select agents and toxins) that could pose a severe threat to public health and safety. The *Agricultural Bioterrorism Protection Act of 2002* requires the United States Department of Agriculture to regulate the possession, use, and transfer of select agents and toxins that could pose a severe threat to animal or plant health, or animal or plant products. The regulations provide that, unless exempted, entities must register with Centers for Disease Control and Prevention (CDC) or Animal and Plant Health Inspection Service (APHIS) if they possess, use or transfer select agents or toxins.

The University of Jos personnel typically do not conduct research involving select agents. Therefore, if a researcher proposes to conduct any work with select agents or other hazardous chemical or physical agents (29 CFR 1910), one copy of a plan describing the proposed work and associated safety protocols will be forwarded to the ACEPRD Advisory Committee for approval consideration; and a second copy will be submitted to the HOD's which will be retained by the faculty.

12.9 Human Blood, Body Fluids and Tissue

If a researcher, and/or student proposes to conduct any laboratory exercise or research project using human blood, fluids (such as urine) or tissues, one copy of a plan describing the proposed work, risk assessment, and associated safety protocols must be submitted to the ACEPRD Advisory Committee and the Research Advisory Committee for pre-approval. Contact the ESO's office for assistance.

Laboratory practices should be followed on the assumption that all human blood, body fluid and tissues are infectious (i.e., universal precautions). The Centers for Disease Control (CDC) and National Institutes for Health recommend that Biological Safety Level Two (BSL-2) standards, containment, and facilities be used for activities involving clinical specimens, body

fluids, and tissues from humans or from laboratory animals infected or inoculated with human material. These standards should also be applied to work with human cells in culture, human serum- derived reagents which may be used as controls and blood obtained from the Red Cross or any health centre.

Universal Precautions

"Universal precautions," as defined by CDC, are a set of precautions designed to prevent transmission of human immunodeficiency virus (HIV), hepatitis B virus (HBV) and other bloodborne pathogens when providing first aid or health care. Under universal precautions, blood and certain body fluids of all patients are considered potentially infectious for HIV, HBV, and other bloodborne pathogens.

Universal precautions apply to blood, other body fluids containing visible blood, semen, and vaginal secretions. Universal precautions **do not apply** to faeces, nasal secretions, sputum, sweat, tears, urine, and vomit unless they contain visible blood. Universal precautions do not apply to saliva except when visibly contaminated with blood or in the dental setting where blood Contamination of saliva is predictable.

Bloodborne Disease Transmission

Bloodborne disease transmission requires the agent to enter the recipient's general blood circulation. This can be through direct blood-to-blood (transfusions) or indirect (dirty needles) transmission. Less obvious routes of transmission are via the mucous membranes of the eye, nose or mouth or through breaks in the skin, which can be a result of simple dermatitis, acne, cuts, abrasions or hangnails. Potential exposure situations are summarized in the following table:

WORK TASK	POTENTIAL EXPOSURE SITUATION
Handling syringes	Accidental self-inoculation, recapping and bending needles after use.
Handling vials, containers of blood, or other potentially infectious material	Breakage of containers may lead to contact with blood and OPIM.
Using blenders and sonicators	Generation of OPIM droplets.
Centrifugation	Splashing blood by opening centrifuge lid before rotor has sopped spinning; unbalanced centrifuge that results in breakage
Collecting and testing specimens of blood and OPIM	Accidental self-infection via spillage of fluids. Aerosol droplet contamination.
Preparing samples of blood or OPIM for microscopic examination	Cutting finger on sharp edges of slide or cover slip.

WORK TASK	POTENTIAL EXPOSURE SITUATION
Working at laboratory benches and other areas where potential infectious	Contact with blood, OPIM at sites that may or may not be contaminated.
Working with specialized glassware and other apparatus during experiments	Breakage of glassware, leakage from lines can lead to contact with OPIM
Source: http://www.unh.edu/research/sites/unh.edu.research/files/docs/EHS/Biosafety/Bloodborne%20Pathogen%20Program%20Rev%200	

Training and Vaccination

The U.S. Occupational Safety and Health Administration (OSHA) standard on Blood-borne Pathogens (29 CFR 1910.1030) sets forth additional procedures and restrictions for working with human blood and bodily fluids. These rules describe engineering controls, safe work practices, personal protective equipment, and disposal requirements for tasks involving blood-borne pathogen exposures. All personnel (both employees and students) who may come in contact with human blood or potentially infectious material in the course of their research activities must receive Blood-borne Pathogens Training. Personnel (including faculty and students) must also provide written documentation of all immunizations (or positive titer) for hepatitis B to the ACEPRD Advisory Committee prior to initiating any research activities that may involve potentially infectious materials (See Section 10.2).

Personal Protective Equipment

- Gloves must be worn when touching blood and body fluids requiring universal precautions, mucous membranes or non-intact skin of all patients and for handling items or surfaces soiled with blood or body fluids to which universal precautions apply.
- Masks, eye protection, face shields must be worn to prevent exposure of mucous membranes of the mouth, nose and eyes during procedures that are likely to generate droplets of blood or body fluids requiring universal precautions.
- Lab coats, gowns, aprons must be worn during procedures that are likely to generate splashes of blood or body fluids requiring universal precautions.

12.9.1 Human Blood

For research involving blood glucose (blood sugar) monitoring or similar blood testing, monitoring can be accomplished in two ways: self-monitoring of blood glucose, and

assisted monitoring where another person assists with or performs the testing for an individual. All persons who assist others with glucose testing must adhere to the following requirements:

- Never use finger stick devices for more than one person;
- Never share blood glucose monitors unless they are cleaned and disinfected after every use, per manufacturer's instructions. If there are no manufacturer's specifications it cannot be shared;
- Syringes, insulin pens, and other medication type cartridges are for single-patient use only and should never be used by more than one person;
- Wear gloves between patient contacts. Change gloves hat have touched potentially blood- contaminated objects or finger stick wounds before touching clean surfaces. Discard gloves in appropriate receptacles;
- Wash hands with soap and water or use an alcohol-based hand rub immediately after removing gloves and before touching other medical supplies intended for use on other persons;
- Report any suspected instances of a newly acquired blood-borne infection to public health authorities;
- Dispose of sharps properly (see Section 6.4.8). Contact ESO's office to arrange for proper disposal of sharps;

12.9.2 Urine

Although urine that is not visibly contaminated with blood is not considered to be "other potentially infect material" (OPIM) as defined by the OSHA standard, there are many pathogens that can live in human urine, including *Leptospira interrogans, Salmonella typhi, Salmonella paratyphi, Schistosoma haematobium, Mycobacteria*, viruses (i.e., CMV, JCV, BKV, adeno, hepatitis), Microsporidia, and others. Thus, all work with urine must be conducted using universal, or standard precautions. All personnel acquiring or collecting human specimens must wear the appropriate Personal Protective Equipment (PPE), including laboratory coat or gown, safety glasses or goggles, and gloves. Personnel collecting or handling the sample should also receive OSHA Bloodborne Pathogen Training, unless they are working with their own bodily fluids. Therefore, experiments and laboratory exercises involving the use of urine are strongly discouraged, and must be pre- approved by the ACEPRD Advisory Committee.

12.9.3 Tissue Culture/Cell Lines

When cell cultures are known to contain an etiologic agent or oncogenic virus, the cell line is classified at the same BSL level as that recommended for the agent.

Established human cell lines which are characterized to be free of contamination from recognized blood-borne pathogens or other potentially infected material (OPIM) are not covered

By OSHA's Blood-borne Pathogen Standard. Written documentation that such cell lines are not OPIM must be provided to the ACEPRD Advisory Committee and will be kept on file by the ESO. Nonetheless, the culture should be handled at BSL-2 containment and researchers must receive blood-borne pathogen training.

12.10 Teratogenic Agents

Research or work with biological agents possessing teratogenic or mutagenic capabilities, such as *Rubella*, herpes, cytomegalovirus or other agents that could cause fetal death, such as *Brucella*, may pose a significant health risk and are prohibited at the University of Jos.

12.11 Transportation of Biological Materials

Do not carry specimen Dewars or covered, polystyrene boxes with dry ice or cryogenic liquid in a private vehicle. Be aware that strict federal and state regulations address the transport of hazardous (biological, chemical, radiological) materials on public roads.

12.12 Biological Waste Treatment and Disposal

Infectious waste includes, but is not limited to, cultures and stocks of infectious agents, pathological wastes, waste human blood and blood products, sharps used in patient and animal care, biological laboratory wastes and dialysis waste. The laboratories at the University of Jos does not typically generate infectious waste, or even when generated is in minimal amounts and therefore does not meet the definition of needing bio-hazardous waste handling procedures. However, microbiological materials, while not considered infectious or bio-hazardous waste by regulatory definitions, can still cause harm to human health. Therefore these biological materials must be disinfected prior to disposal. The University Hazardous Waste Management Procedures contains a detailed description of disposal procedures for biological waste disposal.

12.13 Autoclave Maintenance and Testing

Steam sterilization of materials is a dependable procedure for the destruction of all forms of microbial life. Steam sterilization generally denotes heating in an autoclave using saturated steam under a pressure of approximately 15 pounds per square inch (PSI) to achieve a

chamber temperature of at least 121°C (250°F) for a minimum of 15 minutes. The time is measured after the temperature of the material being sterilized reaches 121°C.

When using a steam autoclave:

- Never autoclave FLAMMABLE, REACTIVE, CORROSIVE, TOXIC or R A D I O A C T I V E MATERIALS;
- Always wear safety glasses, goggles or face shield, lab coat or apron, and heat-protective non-asbestos gloves when opening door or removing items from autoclave;
- Open door slowly, beware of a rush of steam;
- Open door only after chamber pressure returns to zero. Leave door open for several minutes to allow pressure to equalize and for materials to cool;
- Do not mix loads which require different exposure times and exhaust;
- Materials that will melt (e.g., plastic lab ware) could block chamber exhaust drain—place in a shallow stainless steel autoclave pan prior to autoclaving.

To insure sterility of materials and adequate decontamination of wastes, it is important to maintain autoclaves and to train personnel in their proper use. All autoclaves on campus should be checked periodically with chemical strips or by spore testing to make sure they are operating properly and the procedures are adequate for the decontamination of biological waste.

There are three types of indicators associated with autoclaves:

- Chemical colour change indicators change colors after being exposed for a few minutes to normal autoclave operating temperatures of 121°C, and provide a quick visual reference for heat penetration inside the hood. They should be positioned near the centre of each load and toward the bottom front of the autoclave. **Caution:** Chemical indicators alone are not designed to prove that organisms are actually killed during a decontamination cycle;
- Tape indicators are adhesive backed paper tape with heat sensitive, chemical indicator markings. Commonly used heat sensitive markings include diagonal stripes (autoclave tape) and/or the word “sterile”, which only appear when the tape has been exposed for a few minutes to normal autoclave decontamination temperatures. **Caution:** Tape indicators alone are not designed to prove that organisms are actually killed during a decontamination cycle;
- Biological indicators are designed to demonstrate that an autoclave is capable of killing microorganisms. Only *Bacillus stearothermophilus spores* can be used to monitor the bacteriocidal effectiveness of steam autoclaves.

Autoclave Testing Instructions:

- Read supplier's instructions. Place glass ampule of *B. stearothermophilus* spores in the center of a normal waste load;
- Process the load under normal operating procedures;
- Incubate *B. stearothermophilus* at 56-60 degrees Centigrade for 24-48 hours;
- If media is yellow and turbid, the sterilization process has failed. Discontinue use of autoclave until it is repaired and passes re-testing;
- If no colour change has occurred within 72 hours and media is purple, sterilization process is adequate;
- Log and retain test results in a designated logbook kept near the autoclave for three years.

13 WASTE DISPOSAL PROCEDURES

The inappropriate disposal of potentially hazardous chemicals is illegal and can have serious repercussions. The University of Jos **Hazardous Waste Disposal Procedures** provides specific instructions for proper disposal of both hazardous and nonhazardous waste streams (acids/bases, chemicals, biological wastes, sharps, etc.). Under no circumstances should hazardous wastes be discharged into the environment in an effort to "save money", as a matter of "convenience", or due to carelessness in planning preparation, operations or design. Assistance in preventing or resolving such issues is always available from Environmental Health and Safety.

Please remember to label all of your containers regardless of size. Complete labeling of stock solutions is essential. All labels must include the commonly accepted name (NO CHEMICAL FORMULAS), special warnings, individual responsible for the container and the date produced. If you suspect or have knowledge of the inappropriate disposal of potentially hazardous materials or deviations from the following guidance, you should immediately report these concerns to the Environmental Safeguards Officer. No employee of the University of Jos shall be discriminated against or be subject to any reprisal for reporting suspected violations of the College's policies on the disposal of potentially hazardous materials. Anyone who handles chemicals should:

- Attend training when required;
- Refer to the *Hazardous Waste Procedures* when questions arise regarding chemical safety or hazardous waste. **Help is always available from the ESO;**
- Never store more than 10 gallons of hazardous waste in your lab or studio;
- Properly label all stock containers and hazardous waste containers;

- Keep waste containers closed except when adding waste;
- Never mix incompatible wastes (See Section 11);
- Use sturdy, chemically resistant containers to store your wastes;
- Segregate incompatible chemicals at all times—including incompatible wastes—Never store flammables with oxidizers or acids with caustics;
- Use secondary containment bins for all hazardous liquids and liquid wastes;
- DO NOT dispose of hazardous wastes by evaporation, sewer or in the regular trash;
- **Evaporation is not an acceptable waste disposal method.** Only insignificant, residual amounts of liquid associated with lab ware or containers can be treated in this way;
- Notify the HOD or ESO in the event of a significant exposure or spill.
- **Reduce, Reuse, Recycle!**

Definitions

Pathogen: A microbe or microorganism such that can cause disease in an organism.

Animal Pathogen: A microbe or microorganism that can cause disease in animals. Zoonotic agents are animal pathogens that can cause disease in animals and humans.

Authorized Worker: A University of Jos worker, student, visitor or contractor who has acquired the appropriate chemicals and biosafety training and is approved to work with biological or bio-hazardous materials as well as harmful chemicals.

Biological Material: Any material that originates from living organisms, which may be infectious or non-infectious.

Bio-hazardous Material: Any infectious agent or hazardous biological material that present a risk or potential risk to the health of humans, animals, plants, or the environment. The risk can be directly through infection or indirectly through damage to the environment. Bio-hazardous materials include certain types of recombinant DNA, proteins, organisms infectious to humans, animals or plants (e.g. parasites, viruses, bacteria, fungi, prions, protozoa) and biologically active agents (e.g. toxins, allergens, venoms) that may cause disease in other living organisms or cause significant impact to the environment.

Biosafety Cabinet (BSC): An engineering safety control device that is used to provide primary containment and an aseptic work area to protect the health of the worker, the product, and the environment.

Biosafety Plan: A written document that prescribes the health, safety, and biosecurity measures supporting the responsible use and management of organisms, biological materials, bio-hazardous materials and chemicals

Environmental Safeguard Officer (ESO): The individual responsible for developing the University's Biosafety Program in accordance with regulatory requirements and best practices, under the Centre of Excellence in Phytomedicine Research and Development (ACEPRD). Also responsible for application of the plan.

Biotechnology: The application of science and engineering in the direct or indirect use of living organisms or parts or products of living organisms in their natural or modified forms.

Containment Level 1: Containment Level 1 laboratories/facilities require no special design features beyond those suitable for a well-designed and functional laboratory. Biological Safety Cabinets (BSCs) are not required. Work may be done on an open bench top, and containment is achieved through the use of practices normally employed in a basic microbiology laboratory.

Containment Level 2: The primary exposure hazards associated with organisms requiring containment level 2 are through the ingestion, inoculation and mucous membrane route. Agents requiring containment level 2 facilities are not generally transmitted by airborne routes, but care must be taken to avoid the generation of aerosols (aerosols can settle on bench tops and become an ingestion hazard through contamination of the hands) or splashes. Primary containment devices such as BSCs and centrifuges with sealed rotors or safety cups are to be used as well as appropriate personal protective equipment. As well, environmental contamination must be minimized by the use of hand washing sinks and decontamination facilities (autoclaves).

Containment Level 3: Agents requiring containment level 3 may be transmitted by the airborne route, often have a low infectious dose to produce effects and can cause serious or life threatening disease. Containment level 3 emphasizes additional primary and secondary barriers to minimize the release of infectious organisms into the immediate laboratory and the environment. Additional features to prevent transmission of organisms requiring containment level 3 are appropriate respiratory protection, HEPA filtration, or exhausted laboratory air and strictly controlled laboratory access.

Organism: Any living entity (e.g. animals, plants, cell (tissue) cultures, microorganisms).

Microorganisms: Any organism or consortium of organisms of microscopic size and can be unicellular or live in a colony of cellular organisms (e.g. virus, bacteria, protozoa, parasites, fungi, algae).

Genetically Modified Organism (GMO): An organism whose genetic material has been altered using genetic engineering techniques.

Genetically Modified Microorganisms (GMMO): Any organism or consortium of organisms of microscopic size, including bacteria, protozoa, fungi, algae, and viruses, whose genetic material has been altered using genetic engineering techniques.

Human Pathogen: A microbe or microorganism that can cause disease in humans.

Incident: Any undesirable or unplanned event or sequence of events that has had an unintended effect on the health and safety of University of Jos employees, students or contractors, or the safety and security of facilities, operations, and property, or on legal or regulatory compliance.

Infectious Materials or Organisms: An infectious substance as defined in the Human Pathogens and Toxins Act means "a micro-organism or parasite that is capable of causing human disease or an artificially produced hybrid or mutant microorganism that contains genetically altered components of any microorganism capable of causing human disease".

Risk Group 1 Organisms: A category of biological agents or microorganisms which are unlikely to cause disease in healthy workers or animals, or in plants. Risk Group 1 organisms pose a low risk to individuals and to the community.

Risk Group 2 Organisms: A category of human and/or animal pathogens that pose a moderate risk to the health of individuals and a low risk to public health. Risk Group 2 organisms are able to cause serious disease in a human but are unlikely to do so. Effective treatment and preventive measures are available and the risk of spread of disease caused by those pathogens is low.

Risk Group 3 Organisms: A category of human and/or animal pathogens that pose a high risk to the health of individuals and a low risk to public health. Risk Group 3 organisms are likely to cause serious disease in a human. Effective treatment and preventive measures are usually available and the risk of spread of disease caused by those pathogens is low.

Supervisor: A person who is authorized by the university to oversee or direct the work of employees and students. The authority to supervise employees and students is inherent in their job function. Although the university recognizes the ultimate responsibility of performing work in a safe manner lies with the individual employee, supervisors have additional responsibilities, which arise from their role as persons responsible for providing competent supervision and managing the workplace under their authority.

Toxin: A poisonous substance produced by living cells or organisms.

Transgenic Plants and Animals: The results of the transmission of genes within the same species or into other animal or plant species. Worker: A person who is engaged in an occupation in the service of an employer.

Laboratory Technologists: the highest ranking lab employee who oversees the daily running of the laboratory.

APPENDIX A - LABORATORY SAFETY INSTRUCTIONS

General

- Emergency Phone and Phone Numbers: Phone numbers of relevant personnel should be readily available in case of an emergency. These numbers would include those of the HOD's, ESO, lab technologists and others.
- Exits: Note the location of exits in the laboratory and keep in mind the quickest and easiest way to exit the building in case of an emergency. Keep the exits clear of coats, equipment, book bags, etc.

Fire Equipment and Fire Safety

- There are several sources of fire hazards in a chemistry lab. Bunsen burners and hot plates can become extremely hot during the course of an experiment and should always be monitored. The open flame of a Bunsen burners should be kept clear of lab manuals, papers, flammable chemicals, hair, skin, and clothing to name a few. PAY ATTENTION to your surroundings...do not leave ANY experiments unattended;
- Keep laboratory benches clear of clutter. Leave all unnecessary equipment (coats, book bags, text books) away from work areas;
- Chemicals may sometimes ignite during the course of an experiment. During the pre-lab lecture, discuss any specific safety issues involving chemicals. Contain small fires by covering them with a small fire blanket, watch glass or crucible lid. If you have any difficulties, alert your instructor immediately;
- Know how to turn off the gas supply in the event of an emergency;
- There are also fire extinguishers located in the laboratory. Lab staff should be trained on the use of such fire extinguishers. This will be accomplished using the PASS

method (i.e pull pin, aim, squeeze and sweep. This should be demonstrated for lab staff;

- Larger fires may require the evacuation of the laboratory. In these extreme cases, exit the lab, shut the doors, and call the fire department. Leave these types of fires to the professionals;
- The laboratory is also equipped with fire blankets. Note the location of the fire blanket. This is commonly used to surround a person whose clothing has caught fire. The blanket cuts off the oxygen to the fire and smothers it;
- Safety showers provide a large amount of water (in a very little amount of time) and may also be used to put out clothing fires if the fire blanket is too far away. Typically, the safety shower is used when people have been involved in large-scale chemical spills (i.e. if they have been drenched with acid). A person in this situation should also be stripped of their clothing to avoid further chemical contact with the skin.

Chemicals and Chemical Safety

Although many of the chemicals used in this laboratory are somewhat safe, things still can happen. To avoid any accidents in the laboratory, it is important once again to stress the importance of being prepared for class. This means reading over the experiment prior to class and also taking the class seriously.

Horseplay will not be tolerated in the chemistry laboratory. Failure to respect this regulation will mean that students will not be permitted to participate in the laboratory experiment. Some situations that will require dismissal from the laboratory include:

- DO NOT mix any chemicals that you are not asked to. Mixing the wrong chemicals together could lead to unexpected and dangerous chemical reactions;
- DO NOT put any chemicals in or near your mouth. Mechanical pipetting aids should be used. **Mouth pipetting is prohibited**;
- DO NOT throw or "squirt" chemicals at anyone else in the laboratory.

Safety Glasses and Appropriate Attire

Safety glasses must be worn at all times in the laboratory section of the classroom. Safety glasses protect your eyes from chemical splashes, shattered glassware, clumsy neighbors, and a whole list of common mishaps. Safety glasses can be purchased at the bookstore and may be stored in your locker. Failure to respect this regulation will mean that you will not be permitted to participate in the laboratory experiment. Safety glasses cannot be shared and they

will not be loaned out. Safety glasses must also be worn over eyeglasses. Check with your instructor if you can try on a couple of pairs so that proper fitting glasses can be purchased. Contact lenses should be worn with caution during laboratory periods. Ask your instructor for more information.

In addition to wearing safety glasses in the laboratory, pay attention to appropriate clothing to be worn. If possible, wear older clothing in the lab, preferably natural materials such as cotton as opposed to synthetic materials such as polyesters and nylon. Do not wear loose-fitting clothes. Wear comfortable, sturdy shoes...you will be standing while performing experiments.

NO high heels, sandals, open-toed shoes, roller blades, or bare feet will be allowed. Long hair should be tied back.

Safety Equipment

Eyewashes are designed to deliver a stream of water (or saline solution) directly into the eye to remove any chemicals or laboratory debris. You will need assistance from your lab partner to use the eyewashes. Begin by using the eyewash located on the side of the sink. Holding your eyelids open, wash out your eyes for at least 10 to 15 minutes. Eyewash bottles located at the top of the benches contains saline and may be used afterward to soothe eyes. The laboratory is also equipped with fume hoods. Hazardous and volatile chemicals are usually kept here. Also, certain reactions will be performed in the fume hoods. Whenever a reaction is to be done in the fume hood, or if a reagent bottle is kept there, it is safe to assume that is should stay there

Chemical Disposal

During the pre-lab lecture, you will be advised of chemical disposal. Federal government safety guidelines prohibit the disposal of certain chemicals (solvents, organic waste, heavy metals) down the sink. Chemical waste should only be disposed of in appropriately labelled containers. Broken glass and laboratory equipment must also be placed in glass disposal containers. Broken glass, especially chemically contaminated glass, should never be placed in regular trash containers (for the safety of the janitorial staff). Report all chemical spills and accidents (no matter how small) to your instructor.

Common Laboratory Injuries

Cuts: The lab is equipped with a first aid kit. For minor cuts, wash the affected area thoroughly with soap and water, or apply iodine or methylated spirit, remove any foreign particles (if necessary), and bandage. For major cuts, alert your instructor.

Burns: For burns obtained from hot equipment, glassware, or flames, flush the area of the skin for 10 to 15 minutes with cold water. Apply burn cream and bandage from the first aid kit. For chemical burns, wash thoroughly. Alert your instructor for treatment.

Chemical Spills: If chemicals are spilt in the laboratory, your instructor will provide instructions for cleaning them up. If you spill any chemicals on your hands, wash the area for 5 to 10 minutes with large amounts of water. If any rash or burning begins, inform your instructor. If a small amount of chemicals are spilled on clothing, remove the contaminated clothing and wash the skin underneath for 5 minutes with water. For larger spills, it may be necessary to use the safety shower.

Sample Safety Contract: Laboratory instructors should have their students sign a safety contract. It is the responsibility of the instructor to maintain the safety contracts on file. A sample pledge is included below:

ACEPRD, University of Jos
Laboratory Safety Contract
For
Department: …….

I have read the preceding introduction pages and participated in the chemistry laboratory safety lecture.

I understand the safety precautions as well as the course requirements that have been outlined here.

I understand that failure to cooperate with any of the rules outlined here will result in my expulsion from the scheduled experiment and no make-up will be available.

Lab section _____

Name:_____

Date:_____ Signature:_____

NOTE: It is important to note that this Safety Contract may or may not be used depending on the needs of the Laboratories or University regulations.

APPENDIX B —SELECTING APPROPRIATE GLOVES

Use non-latex gloves, such as nitrile or vinyl. Gloves should be replaced immediately if they are contaminated or torn. In situations involving extremely hazardous chemicals, double gloves are recommended. Gloves should be carefully selected for their degradation and permeation characteristics to provide proper protection. Permeation describes how some chemicals can pass through a glove on a molecular level. The thin, vinyl or nitrile gloves, popular for their dexterity, are not appropriate for highly toxic chemicals or solvents. Key concepts to remember include:

- **Understand the toxicity and hazards of the materials you work with:** Consult the MSDS for each chemical/product you work with for additional information on glove selection. Use special care handling chemicals with high acute toxicity and those with significant chronic effects (known carcinogens etc).
- **All gloves are permeable:** Permeation is dependent on many factors including the material handled, extent and length of contact. Glove composition, thickness, fatigue and conditions of use also factor into glove effectiveness.
- **There is no such thing as an "ideal" chemically resistant glove** : Some gloves may offer superior protection but limit dexterity and tactile sensitivity or are prone to tears or punctures. Sometimes the best glove is actually two gloves worn together. Reusable gloves (ex. nitrile, neoprene, butyl or Viton) can be worn over flexible laminate gloves to combine the advantages of both.
- **Consult the manufacturer's chemical resistance guide:** Chemical resistance varies according to manufacturer. In most cases the information provided includes degradation (a measure of the gloves tendency to swell, discolour or otherwise change due to chemical contact) and permeation. Chemicals can oftentimes permeate gloves without causing visible change. Breakthrough is the time elapsed between first contact outside the glove and detection inside.
- **Understand the difference between reusable and disposable gloves:** Disposable gloves are thin single use gloves generally 4 - 8 mils thick compared to reusable gloves which are 18 - 28 mils thick (1 mil = 1/1000 inch). Disposable gloves are not suitable for handling aggressive or highly hazardous chemicals and should never be re-used. Disposable gloves can provide barrier protection where contact with chemicals is not likely. Whenever a disposable glove comes in contact with hazardous chemicals it

should be removed, followed by thorough hand washing and new gloves for continued work. Bag contaminated gloves for disposal as hazardous waste.

- **Care of reusable gloves:** In the lab most chemical handling does not require immersion or extensive/prolonged contact. As a result it is normally not necessary to replace heavy-duty gloves after each use. Before removing reusable gloves, thoroughly rinse them off and then allow to air dry. Inspect reusable gloves before each use for discoloration, cracking at flexion points or damage (punctures or pin holes) - discard if discovered. If you suspect they have become contaminated bag them for disposal as hazardous waste.

Glove Materials

- Viton™ - Excellent resistance to chlorinated and aromatic organic solvents – expensive.
- Butyl - Good resistance to aldehydes, ketones and esters – expensive.
- Nitrile - Wide range of applications with puncture and abrasion resistance.
- Neoprene - Wide range of resistance to acids, caustics, and alcohols.
- PVC - Resists acids and caustics but not organic solvents.
- Natural rubber/latex - Minimal chemical resistance, often combined with other materials for a broad range of applications. Latex allergies limit widespread use.
- Flexible laminates - North's Silver Shield/4H® glove is a five layer laminate material that offers the best chemical resistance in most cases. It is best used as an inner liner under re- usable gloves to maintain dexterity and tactile sensitivity when handling extremely hazardous materials.

The following websites provide chemical protective clothing (CPC) recommendations for the chemicals listed in the *NIOSH Pocket Guide to Chemical Hazards, June 1997 Edition* (Publication No. 97-140): http://www.cdc.gov/niosh/prot-cloth ncpc1.htm and http://www.cdc.gov/niosh/prot-cloth/ncpc2.html.

Glove Compatibility Charts

The following are links to various companies providing gloves. Glove compatibility or chemical resistance charts for those gloves are supplied by those companies. Please use these charts to ensure the gloves being used to handle chemicals are providing adequate protection to the wearer. All chemicals will not be listed on these charts. Note that two similar gloves supplied by two separate manufacturers may not provide the same level of protection to a

specific chemical. Therefore, it is necessary to consult the manufacturer's specific compatibility chart for the brand of gloves being used.

Understanding terms used in glove compatibility charts:

- Breakthrough time: Time it takes for the chemical to travel through the glove material. This is only recorded at the detectable level on the inside surface of the glove.
- Permeation Rate: Time it takes for the chemical to pass through the glove once breakthrough has occurred. This involves the absorption of the chemical into the glove material, migration of the chemical through the material, and then deabsorption once it is inside the glove.
- Degradation rating: This is the physical change that will happen to the glove material as it is affected by the chemical. This includes, but is not limited to swelling, shrinking, hardening, cracking, etc. of the glove material.

Compatibility charts' rating systems will vary by the manufacturer's design of their chart. Many use a color code, where red = bad, yellow = not recommended, green = good, or some variation this scheme. A letter code may be used, such as E = excellent, G = good, P = poor, NR = not recommended. Any combination of these schemes may be used, so please understand the chart before making a decision on the glove to be used.

APPENDIX C – INCIDENT REPORT AND SPILL REPORT FORMS

University of Jos
PMB 2084, Jos, Plateau State.
Nigeria.

Incident Report Form

Location of Incident: _____

Incident Date: _____ Incident Time: _____

Name of Person(s) Involved: _____

Address: _____ Phone Number: _____

Sex (Male/Female): _____ Needing Medical Attention (Yes/No): _____

Description of Incident (including names of individuals involved and nature of incident)

_____

_____

_____

_____

_____

Prepared By: _____ Date: _____

Sign: _____

NOTE: It is encouraged that all incidents should be reported.

APPENDIX D –INCOMPATIBLE CHEMICALS

Chemical	*Incompatible with:*
Acetic Acid	Chromic acid nitric acid hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Concentrated nitric and sulfuric acid mixtures
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali and alkaline earth metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, magnesium, calcium, lithium, halogens, sodium, potassium
Aluminum (powdered)	Chlorinated hydrocarbons, halogens, carbon dioxide organic acids
Ammonia (anhydrous)	Mercury (e.g. in manometers), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, powered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Calcium carbide	Water, alcohol
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic Acid	Acetic acid, naphthalene, camphor, glycerol, alcohol, turpentine, flammable liquids in general.
Chlorine	See bromine
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	All other chemicals
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids, oxidizing gases
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous) hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Mercuric oxide	Sulfur
Nitrates	Acids (especially sulfuric acid)
Nitric acid (concentrated)	Acetic acid, alcohols, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids and gases, copper, brass, any heavy metals

Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids and gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
Peroxides organic	Acids (organic or mineral), avoid friction or shock, store cold
Phosphorous (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate	Sulfuric and other acids, see also chlorates
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fluminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide,
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate, similar compounds of
Tellurides	Reducing agents
Zinc powder	Sulfur

APPENDIX E – PEROXIDE-FORMING CHEMICALS

There are four classes of peroxide-forming chemicals based upon the peroxide formation hazard: More information is available in the National Safety Council Publication, "Recognition and Handling of Peroxidizable Compounds".

<table>
<tr><th colspan="5">Class A - Severe Peroxide Hazard</th></tr>
<tr><td colspan="2">Spontaneously decompose and become explosive with exposure to air without concentration</td><td>Butadiene (liquid monomer)
Chloroprene (liquid monomer, chlorobutadiene)
Divinyl acetylene</td><td>Isopropyl ether
Potassium amide
Potassium metal</td><td>Sodium amide (Sodamide)
Tetrafluoroethylene (liquid monomer)
Vinylidene chloride</td></tr>
<tr><td>Date received:</td><td>1 year</td><td colspan="3" rowspan="2"></td></tr>
<tr><td>Date opened:</td><td>3 months</td></tr>
<tr><th colspan="5">Class B – Concentration Hazard</th></tr>
<tr><td colspan="2">Require external energy for spontaneous decomposition. Form explosive peroxides when distilled, evaporated</td><td>Acetal
Acetaldehyde
Benzyl alcohol
2-Butanol (t-butyl alcohol)
Cumene
Cyclohexanol
Cyclohexene
2-Cyclohexen-1-ol (propanoate)
Decahydronaphthalene
Diacetylene
Dicyclopentadiene</td><td>Diethylene glycol dimethyl ether (diglyme) Dioxanes
1,4 -Dioxane
Ethyl ether (diethyl ether)
Ethylene glycol dimethyl ether (glyme)
Furan
4-Heptanol
2-Hexanol
Methylacetylene
3-Methyl-1-butanol</td><td>Methyl isobutyl ketone
4-Methyl-2-pentanol
2-Pentanol
4-Penten-1-ol
1-Phenylethanol
2-Phenylethanol
2-Propanol
Tetrahydrofuran
Tetrahydronaphthalene
Vinyl ethers
Other secondary alcohols</td></tr>
<tr><td>Date received:</td><td>1 year</td><td colspan="3" rowspan="2"></td></tr>
<tr><td>Date opened:</td><td>6months</td></tr>
<tr><td colspan="2"></td><td colspan="3">(more commonly used chemicals in bold)</td></tr>
<tr><th colspan="5">Class C – Shock and Heat Sensitive</th></tr>
<tr><td colspan="2">Highly reactive and can auto-polymerize as a result of internal peroxide accumulation.
The peroxides formed in these reactions are</td><td>Acrylic acid Acrylonitrile
Butadiene* (gas)
Chlorobutadiene (Chloroprene)*</td><td>Chlorotrifluoroethylene
Methyl methacrylate
Styrene
Tetrafluoroethylene* (gas)</td><td>Vinyl acetate
Vinyl acetylene (gas) Vinyl chloride (gas) Vinyl pyridiine
Vinylidene chloride</td></tr>
<tr><td>Date Received:</td><td>1 year</td><td colspan="3" rowspan="2"></td></tr>
<tr><td>Date Opened:</td><td>6months</td></tr>
<tr><td colspan="2"></td><td colspan="3">*When stored as a liquid, the peroxide-forming potential of certain monomers increases. They may become hazardous even if never opened.</td></tr>
</table>

Class D – Potential Peroxide Forming Chemicals				
May form peroxides but cannot be clearly categorized in Class A,		Acrolein	Diallyl ether	n-Hexyl ether
		Allyl ether	p-Di-n-butoxybenzene	o,p-Iodophenetole
		Allyl ethyl ether	1,2-Dibenzyloxyethane p-	Isoamyl benzyl ether
Date received:	Only if peroxides are present	Allyl phenyl ether	Dibenzyloxybenzene	Isoamyl ether Isobutyl
		p-(n-Amyloxy)benzoyl chloride	1,2-Dichloroethyl ethyl	vinyl ether Isophorone
Date opened:		n-Amyl ether	ether	b-
		Benzyl n-butyl ether	2,4-Dichlorophenetole	Isopropoxypropionitril e
		Benzyl ether Benzyl ethyl ether	Diethoxymethane	Isopropyl-2,4,5-
		Benzyl methyl ether Benzyl-1-	2,2-Diethoxypropane	trichlorophenoxy acetate
		napthyl ether	Diethyl ethoxymethylene	n-Methylphenetole
		1.2-Bis(2-chloroethoxyl)	malonate	2-
		ethane	Diethyl fumarate Diethyl	Methyltetrahydrofuran
		Bis(2-ethoxyethyl)ether	acetal Diethylketene	3-Methoxy-1-butyl acetate
		Bis(2-(methoxyethoxy)ethyl)	Diethoxybenzene (m-	2-Methoxyethanol
		ether	,o-,p-)	3-Methoxyethyl acetate
		Bis(2-chloroethyl)ether Bis(2-	1,2-Diethoxyethane	2-Methoxyethyl vinyl ether
		ethoxyethyl) adipate Bis(2-	Dimethoxymethane	Methoxy-1,3,5,7-
		methoxyethyl)	1,1-Dimethoxyethane	cyclooctatetraene
		carbonate	Di(1-propynl) ether	b-Methoxypropionitrile m-
		Bis(2-methoxyethyl) ether	Di(2-propynl) ether	Nitrophenetole
		Bis(2-methoxyethyl)	Di-n-propoxymethane	1-Octene
		phthalate	1,2-Epoxy-3-	Oxybis(2-ethyl acetate)
		Bis(2-methoxymethyl)	isopropoxypropane	Oxybis(2-ethyl
		adipate	1,2-Epoxy-3-	benzoate)
		Bis(2-n-butoxyethyl)	phenoxypropane	b,b-Oxydipropionitrile
		phthalate	p-Ethoxyacetophenone	1-Pentene
		Bis(2-phenoxyethyl) ether	1-(2-Ethoxyethoxy)ethyl	Phenoxyacetyl chloride a-
		Bis(4-chlorobutyl) ether	acetate	Phenoxypropionyl
		Bis(chloromethyl) ether	2-Ethoxyethyl acetate	chloride
		2-Bromomethyl ethyl ether	(2-Ethoxyethyl)-a- benzoyl	Phenyl-o-propyl ether p-
		beta-Bromophenetole o-	benzoate	Phenylphenetone
		Bromophenetole	1-Ethoxynaphthalene	n-Propyl ether
		p-Bromophenetole	o,p-Ethoxyphenyl	n-Propyl isopropyl ether
		3-Bromopropyl phenyl ether	isocyanate	Sodium 8-11-14-
		tert-Butyl methyl ether	1-Ethoxy-2-propyne	eicosatetraenoate
		n-Butyl phenyl ether	3-Ethoxypropionitrile	Sodium ethoxyacetylide
		n-Butyl vinyl ether	2-Ethylacrylaldehyde	Tehtrahdyropyran

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