

CHEMICAL HYGIENE PLAN

Biology Department
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I. Authorship Purpose

The purpose of the Biology Department's Chemical Hygiene Plan is to establish procedures, equipment, personal protective equipment, and work practices that will protect employees, students, and visitors to Biology Department laboratories from health hazards presented by hazardous chemicals and laboratory equipment. All laboratory workers- faculty, staff and students- should be given ready access to this plan. This plan is intended to comply with OSHA Standard 29 CFR 1910.1450.

(https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106).

II. Governmental Regulation

The Biology Department Chemical Hygiene & Laboratory Equipment Safety Plan was written to comply with OSHA Standard 29 CFR 1910.1200 with Appendices A, B, and E

(https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099), and

OSHA Standard 29 CFR 1910.1450 with Appendices A and B

(https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106).

An additional source used for this document, which addresses both chemical and equipment safety is Prudent Practices for Handling Hazardous Chemicals in Laboratories: Handling and Disposal of Chemicals, published by the National Research Council (2011). An earlier (1981) publication of Prudent Practices was cited in the OSHA Laboratory Standard, specifically in Appendix A of Standard 29 CFR 1910.1450, because of "its wide distribution and acceptance

and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council."

The OSHA Hazard Communication Standard (OSHA Standard 29 CFR 1910.1200) requires employers with hazardous chemicals in the workplace to provide information about those chemicals and safety training for their employees.

III. Scope, Content, Application

According to Prudent Practices for Handling Hazardous Chemicals in Laboratories: Handling and Disposal of Chemicals (2011), a chemical hygiene plan should contain these elements:

- employee information and training about the hazards of chemicals in the work area, including how to detect their presence or release, work practices and how to use protective equipment, and emergency response procedures;
- the circumstances under which a particular laboratory operation requires prior approval from the employer (administrator, director, manager);
- standard operating procedures for work with hazardous chemicals;
- criteria for use of control measures, such as engineering controls or personal protective equipment;
- measures to ensure proper operation of fume hoods and other protective equipment;
- provisions for additional employee protection for work with "select carcinogens" (as defined below) and for work with reproductive toxins or substances that have a high degree of acute toxicity; provisions for medical consultations and examinations for employees; and,
- designation of a chemical hygiene officer.

In addition, this plan contains safety information regarding laboratory equipment commonly found in biology laboratories. This plan applies to all JMU Biology department employees and students, as well as onsite outside contractors and visitors whose work or activities inside a biology department laboratory may expose them to hazards associated with biological laboratories.

IV. Safety Committee

The committee will address laboratory safety issues, be composed of the Biology department Chemical Hygiene Officer, the departmental laboratory coordinators, and one or more members of the Biology department faculty, and will be established for the purpose of

- approving all Biology department safety documents, making recommendations for changes to be made when deemed necessary for OSHA compliance;
- approving the overall Biology department safety program, as established by the Chemical Hygiene Officer;
- discussing departmental safety and waste disposal issues; and
- analyzing any incidents that occurred since the last meeting, such as accidents that may or may not have resulted from violations of the safety regulations, or issues of neglect or enforcement on the part of faculty, staff, or students.

In addition, the overall chemical hygiene and safety program, as represented in this document, will be reviewed by the university's Environmental Health Coordinator (EHC). Though the EHC will not be a standing member of the Safety Committee, he/she may be asked to join the committee for selected meetings.

This committee will meet formally at least once during each academic year.

V. Definitions

Action Level: a concentration designated in OSHA Standard 29 CFR 1910 for a specific substance, calculated as an eight-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

Chemical Hygiene and Safety Officer: employee who is designated by the department, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Biology Department Chemical Hygiene Plan. Currently, Robert Walters is the Chemical Hygiene and Safety Officer.

Designated Area: area that may be used for work with "select carcinogens," reproductive toxins or substances, which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

Employee/Student: an individual employed in a laboratory workplace, or a student of the Biology department, who may be exposed to the hazards associated with working with chemicals in the course of his/her assignments, classroom or research duties.

Hazardous Chemical: chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute and chronic health effects may occur in exposed persons.

Hazardous Waste may be defined as substances, which meet the EPA RCRA (1976) proposal criteria of toxicity, ignitability, corrosiveness, or reactivity.

Health Hazard: includes chemicals, which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers (allergens), hepatoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems and agents which damage the lungs, skin, eyes, or mucous membranes.

High Acute Toxicity Chemical: chemical that may be fatal or cause damage to target organs because of a single exposure or exposures of short duration.

Laboratory: workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

Laboratory Fume Hood: five-sided enclosure with a moveable sash or fixed partial enclosed on the remaining side. It is constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory. It allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the body other than hands and arms.

Laboratory Scale: work with substances in which the containers used for reactions, transfers, and other handling of substances is designed to be easily manipulated by one person.

Medical Consultation: a consultation which takes place between an employee (or student, or visitor to a Biology department laboratory) and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

Oxidizer: a chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Reproductive Toxin: chemicals that affect human reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Select Carcinogen: substance that meets one of these criteria:

1. Regulated by OSHA as a carcinogen.
2. Listed under the category "known to be a carcinogen" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP).

3. Listed under Group 1 (carcinogenic to humans) by the International Agency for Research on Cancer Monographs (IARC).
4. Listed in either Group 2A or 2B in IARC or under the category "reasonably anticipated to be carcinogens" by the NTP and causes statistically significant tumor incidence in experimental animals.

Visitor: a guest person, not employed by the biology department and not a student of the biology program, who enters a biology laboratory.

VI. Responsibilities

Dean of the College of Science and Mathematics (CSM)

- Oversees and administers all aspects of the college, which includes the Department of Biology.

Biology Department Head:

- Ultimately responsible for chemical hygiene and safety for the department, and must, with other administrators, provide continuing support for departmental chemical hygiene and safety.
- Appoints the Chemical Hygiene Officer (CHO).

Chemical Hygiene and Safety Officer:

- Works with administrators and other employees, as well as students, to develop and implement appropriate chemical hygiene policies and practices.
- Ensures that regular, formal chemical hygiene and housekeeping inspections, including routine inspections are maintained, and sees that appropriate audits are completed.
- Helps faculty and students develop precautions and adequate facilities for work anticipated to be done in all laboratories.
- Informs students, faculty and staff, and the Biology Department Head of safety infractions and other laboratory chemical and equipment problems.
- Seeks ways to continually improve the Biology Department Chemical Hygiene Plan.

Departmental Safety Committee:

- Works with the chemical hygiene officer, administrators, and other employees to develop and implement appropriate chemical hygiene policies and practices.

Faculty Members/Laboratory Coordinators/Laboratory Instructors/Research Advisers:

- Responsible for chemical hygiene and safety in the particular laboratory under his/her jurisdiction at a particular time. Such times include
 - meetings of formal laboratory classes
 - instructional sessions for lab supervisors and instructors
 - lab exercise set-up periods
 - faculty-student research sessions
- Ensure that laboratory workers know and follow the chemical hygiene and safety rules, that protective equipment is available and is in working order, and that appropriate training has been provided.
- Know the current legal requirements for controlled substances used in the laboratory.
- Determine the required levels of protective apparel and equipment by personnel occupying a laboratory at any time.
- Ensure that the facilities and proper training needed for the use of hazardous equipment and materials being used in the laboratory are adequate.

Laboratory Workers and Students:

- Responsible for planning and conducting all operations in accordance with the Biology Department Chemical Hygiene Plan, as directed by those persons in charge of the laboratory.
- Develop good personal chemical hygiene and safety habits as stated in the Standard Laboratory Practices and Safety Rules document, which is given to new Biology Department faculty, graduate assistants, and student laboratory assistants; as well as to students as part of their course syllabi.

VII. Information & Training

Information: Each laboratory instructor/coordinator or research adviser is responsible for ensuring that this information is communicated to his/her employees and students under his/her direction:

1. The location and availability of the OSHA Laboratory Standard (29 CFR 1910.1450) with Appendices A, B and E (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106)
2. The location and availability of the Biology Department Chemical Hygiene Plan (<http://www.jmu.edu/biology/safety.shtml>)
3. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory
4. Location and availability of material safety data sheets (SDS) that provide information on the hazards, safe handling, storage and disposal of chemicals. SDS sheets specific for each laboratory are available at <https://jmu.kha.com/>.

Training: Each laboratory instructor/coordinator or research adviser is responsible for ensuring that laboratory employees, e.g., student laboratory assistants, state-classified full time employees and part-time employees, receive adequate training. This training should include

- physical and health hazards of chemicals in the work area
- measures employees and students can take to protect themselves from such hazards, including specific procedures that have been implemented to protect laboratory employees from exposure to hazardous chemicals including appropriate work practices, emergency response procedures, and personal protective equipment to be used
- applicable details of the Biology Department Chemical Hygiene Plan

The frequency of refresher information and training may be determined by the laboratory supervisor/coordinator, research advisor, or the Chemical Hygiene Officer.

A copy of the biology safety training form, “Biology Online Lab Safety Form” (<http://www.jmu.edu/biology/safety.shtml>) containing safety information concerning chemical safety issues, will be provided during safety training sessions held at the beginning of each semester to

- all persons (students, employees) directed to oversee any section of Biology Department laboratory courses
- any student/employee involved in laboratory preparations
- any student/employee involved in laboratory-related project
- any student enrolled in a laboratory course

VIII. Permissible Exposure Limits

For laboratory uses of OSHA regulated substances, the employer shall ensure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits (PEL) specified in OSHA Standard 29 CFR part 1910, Z tables

(https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099). **Employee Exposure Determination**

Initial Monitoring: Initial employee exposure monitoring should be conducted when there is reason to believe that exposure levels for OSHA-regulated substances routinely exceed the action level (or in the absence of an action level, the PEL).

Periodic Monitoring: If the initial monitoring discloses employee exposure over the action level (or PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

Termination of Monitoring: Monitoring may be terminated in accordance with the relevant standard.

Employee Notification of Results: The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing.

Records: Records of exposure monitoring results should be maintained by employer for 30 years and be accessible to employees or their representatives.

IX. Control Measures & Safety Equipment

Laboratory Fume Hoods: Laboratory fume hoods should

1. be used for work with hazardous chemicals, especially toxic chemicals that have low air concentration limits, or that have high vapor pressures; including flammable and volatile solvents.
2. provide 2.5 linear feet of space per person for every 2 workers who spend most of their time working directly with hazardous chemicals;
3. provide a face velocity (with sash fully open) of 80 to 120 feet per minute (fpm)
4. not be used as storage areas for chemicals, apparatus or other materials; and
5. not be used to evaporate solvents
6. be used such that work inside the hood is conducted at least six inches from the front edge of the hood.
7. be kept with hood sashes lowered at all times except when necessary to raise them to adjust apparatus inside the hood.
8. be used with the hood fan kept "on" whenever a chemical is inside the hood, whether or not any work is being done in the hood.

Any hood with inadequate performance should be taken out of service, tagged out, and repaired immediately.

Solid objects must not be allowed to enter the exhaust duct of the hood.

Safety Equipment:

Most laboratories are equipped with, or have readily accessible

- an eyewash fountain and safety shower
- protective apparel compatible with the required degree of protection for substances being handled
- a fire extinguisher
- a first-aid kit
- spill control kits, if appropriate

Each safety apparatus should be located so that they can be reached readily, and access must not be restricted or blocked in any way. In addition, fire alarms for emergency use should be available nearby.

Eyewash fountains and safety showers should be tested and flushed once a month to see that they are functioning properly.

Fire extinguishers will be inspected monthly by JMU Facilities Management personnel.

X. Chemical-Specific Safety Procedures

Reproductive Toxins:

Reproductive toxins should be handled only in a chemical fume hood, using appropriate protective apparel (especially suitable gloves) to prevent skin contact.

Reproductive toxins should be properly labeled and stored in well-ventilated areas in secondary containers.

Supervisors/instructors should be notified of all incidents of exposure or spills.

High Acute Toxicity Chemicals (Supplemental rules to be followed in addition to those mentioned above):

Use and store these chemicals in areas of "RESTRICTED ACCESS" that are posted with special warning signs. These areas should include a chemical fume hood (with a face velocity of at least 80-120 linear feet/minute) or other containment device for procedures that may generate aerosols or vapors containing the substance.

Use gloves, goggles, long sleeves and other protective apparel as needed to avoid skin contact. Always wash hands after working with these chemicals.

Maintain records of the amounts of these materials on hand and amounts used.

Ensure that at least two people are present at all times if a compound in use is highly toxic.

Be prepared for accidents and spills. Store breakable containers of these substances in chemically resistant trays. Cover work and storage surfaces with removable, absorbent, plastic-backed paper.

If a major spill occurs outside the hood, evacuate the area; ensure that cleanup personnel wear suitable protective apparel and equipment.

Contaminated clothing and shoes should be disposed of using according to established chemical disposal procedures.

Store contaminated waste in closed, suitably labeled secondary containers (for liquids, plastic bottles half-filled with vermiculite).

The laboratory supervisor/instructor, as well as the Chemical Hygiene and Safety Officer, must be notified of all incidents of exposure or spills.

The controlled work area, including any equipment and glassware, should be decontaminated before normal work in that area is resumed.

NO CONTAMINATED WASTE MATERIALS SHOULD BE PLACED IN STANDARD LABORATORY TRASH RECEPTACLES.

Select Carcinogens (Supplemental rules to be followed, in addition to all those mentioned above):

Conduct all transfers and work with these substances in a designated area--a restricted access hood, glove box or portion of a lab designated for use of highly toxic substances, for which all people with access are aware of the substance being used and necessary precautions. The designated area should be conspicuously marked with warning and restricted access signs. Each laboratory supervisor or instructor must prepare a plan for use and disposal of these materials.

All containers of carcinogenic substances should be properly labeled with identity and warning labels.

Store containers of these chemicals in ventilated, limited access areas in appropriately labeled, chemically resistant secondary containers.

If using toxicologically significant quantities of a select carcinogen (see page 4) on a regular basis (3 times per week or more), consult the JMU Risk Management office concerning desirability of regular medical surveillance.

When cleaning a spill, use a wet mop instead of dry sweeping if the toxic substance is a dry powder.

When using a positive pressure glove box, thoroughly check for leaks before each use. Trap exit gases or filter them through a HEPA filter and then release into the hood.

Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in secondary container under the supervision of the laboratory supervisor/instructor.

Decontaminate any equipment, including glassware, in the hood before removing them from the controlled area. Decontaminate the controlled area before resuming normal work there.

When leaving the area, remove protective apparel and wash hands, forearms, face and neck.

Flammables:

Never heat flammable liquids with an open flame or hot plate. Use a heating mantle, steam bath or hot water bath.

Never use or store flammable chemicals near any source of ignition, spark, or open flame.

Handle solvents in a chemical fume hood or a well-ventilated area.

Ground containers when transferring from one container to another if the potential for sparking exists.

Store flammable liquids in appropriate safety cabinets and/or safety cans.

Corrosives/irritants:

Concentrated acids should be stored in appropriate acid safety storage cabinets. Inorganic acids, such as sulfuric, nitric and hydrochloric, should be stored separately from organic acids, such as acetic.

Acids and bases (including strong alkaline solutions) should not be stored in close proximity. Since corrosive chemicals are highly reactive, dissolve and corrode (naturally) many different materials, and because some give off dangerous fumes,

- acids and bases are to be handled in an exhaust hood or a well-ventilated area.
- acids and bases are to be stored in appropriate cabinets; acids stored separately from bases.
- Because corrosives give off heat when diluted with water, one should always add acid to water. Doing so allows the heat to spread through the water instead of being concentrated in a small volume.

Mixing strong acids with strong bases is dangerous, and must be done slowly and with caution in a fume hood.

Since strong acids react with metals to generate explosive hydrogen gas, care must be used in dissolving metals in acids. Also, because mixing acids with solvents may lead to explosions;

appropriate caution must be taken when strong oxidizers-such as nitric acid-and solvents are in proximity. Solvents and oxidizers must be segregated.

Compressed gases, liquefied gases, and cryogenic liquids:

All gas lines leading from a compressed gas supply should be labeled clearly to identify the gas. Labels should be color-coded to distinguish hazardous gases from those that are inert. Cylinders should be transported carefully, not dragged, rolled, slid, or allowed to strike each other forcefully. They should be transported on wheeled cylinder carts with retaining straps or chains.

Once in place, cylinders should be secured firmly and individually, by means of clamp and belt or chain, to a wall or lab bench. The valve handle at the top should be accessible at all times. The cylinder valve should be opened slowly and only when a proper regulator is in place.

Leak-testing should be performed when a problem with a cylinder is suspected. To check for leaks, a flammable gas leak detector, soapy water, or a 50% glycerin/water solution, may be used. If a leak at the cylinder valve handle cannot be remedied by tightening a valve gland or a packing nut, emergency action should be taken, which includes notification of campus police and the supplier.

All sources of ignition should be kept away from cylinders of flammable gases, e.g., oxygen, hydrogen, methane and acetylene.

Special precautions with gas cylinders:

- Cylinders should be labeled as to their contents. Reliance on the manufacturer's color code is not advised.
- Gas cylinders should be strapped or chained to a wall or bench top.
- When a cylinder is no longer in use, the tank valve should be closed; pressure in gas regulator released; the regulator removed; and the tank valve should be capped. Empty cylinders should be segregated from full (or partially full) ones. They should be strapped or chained properly until they are returned to the supplier.
- Gas cylinders, when stored, should be kept away from other stored chemicals.
- Incompatible gases should be stored separately. Flammable gases should be stored away from reactive gases, including oxidizers and corrosives.
- Signs should be posted conspicuously in areas in which flammable compressed gases are stored. For example,

ACETYLENE-FLAMMABLE GAS
NO SMOKING-NO OPEN FLAMES

Because of the special risk of eye and skin contact of personnel who work with cryogenic liquids (e.g., liquid nitrogen, helium and argon),

- eye protection-preferably a face shield-should be worn,
- gloves impervious to the fluid must be worn, and
- the area must be well-ventilated.

XI. Standard Operating Procedures to Ensure Biological Safety

Biological agents (such as bacterial cultures, cultured cells and virus stocks) should be purchased (or otherwise received) in accordance with the biology department's Biosafety regulations presented in this document.

Biological agents deemed to be hazardous, purchased (or otherwise received), shall be stored in accordance with the biology department's Biosafety regulations presented in this document.

Control Measures and Safety Equipment

Laboratory ventilation should provide a source of air for breathing and for input to local ventilation devices and not be relied on for protection from toxic substances released into the laboratory.

Biological Safety Cabinets

Biological safety cabinets referred to in this section are classified as Class I and Class II cabinets. Additional information on biological safety cabinets is published as a CDC-NIH web page: <http://www.cdc.gov/od/ohs/biosfty/bsc/bsc.htm>

Class I - a ventilated cabinet for personnel protection having an inward flow of air away from the operator. The exhaust air from this cabinet is filtered through a high efficiency particulate air/HEPA filter. This cabinet is used in three operational modes: (i) with a full-width open front, (ii) with an installed front closure panel (having four 6-inch diameter openings) without gloves, and (iii) with an installed front closure panel equipped with arm-length rubber gloves. The face velocity of the inward flow of air through the full-width open front is 75 feet per minute or greater.

Class II - a ventilated cabinet for personnel and product protection having an open front with inward air flow for personnel protection, and HEPA filtered mass recirculated air flow for product protection. The cabinet exhaust air is filtered through a HEPA filter. The face velocity of the inward flow of air through the full-width open front is 75 feet per minute or greater. Design and performance specifications for Class II cabinets have been adopted by the National Sanitation Foundation, Ann Arbor, Michigan (www.nsf.org).

Prior to being used with microbial pathogens or for animal cell culture / virus work, these cabinets shall be tested and certified by a representative of a company that specializes in biosafety cabinet certification and decontamination. Thereafter, the cabinet shall be recertified annually. A biosafety cabinet certifier may be found by searching the website <http://info.nsf.org/Certified/Biosafety-Certifier/>.

Biological Agents

Resources for the information in this section include a document posted by the University of Colorado, Boulder Institutional Biosafety Committee as

“IBC Requirements for Laboratory Operating Practices, Physical Containment, and Training for Research Involving Biological Agents.” (Document footer: EHS/IBC doc. 2/16/07 dd)
(<http://ehs.colorado.edu/BioSafetyDocs/IBCGuidContanLabs.pdf>)

Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition
(<http://www.cdc.gov/biosafety/publications/bmb15/>)

Establishing Appropriate Biosafety Laboratory Environments (p. 542-546) in *Biological Safety: Principles and Practices*. 2006. Fleming and Hunt (editors) 4th edition. ASM Press Washington DC

Biosafety Guidelines for Handling Microorganisms in the Teaching Laboratory: Development and Rationale (May 2013) Emmert & ASM Task Committee on Laboratory Biosafety in *Journal of Microbiology & Biology Education*.

Changes were made as needed to apply to facilities in the biology department to which this safety document applies. Most importantly, these ‘standards’ parallel the current NIH guidelines.

The James Madison University Institutional Biosafety Committee (IBC), the Biology department’s Chemical Hygiene and Safety officer, and the University Environmental Health Coordinator, require that the following standard and special microbiological practices, physical containment or laboratory design, containment equipment, and training be implemented when using organisms containing recombinant DNA or biological agents that are known or potential biohazards. These requirements include hygienic and operational practices that are critical in providing for a safe work environment and assuring a viable research product is produced. These practices are also necessary for minimizing and/or eliminating the risk of occupational exposure to infectious and potentially infectious substances.

The Principal Investigator is responsible for having their laboratory area meet the specified requirements for the biosafety containment level that corresponds to the biological agents in use. Failure to meet these requirements will result in a review by the IBC. The Principal Investigator will work with the IBC to correct all deficiencies in a timely manner.

Standard Practices and Training

The first principle of containment is strict adherence to good microbiological practices. Consequently, all personnel directly or indirectly involved in experiments using recombinant DNA shall receive adequate instruction. At a minimum, these instructions

include training in aseptic techniques and in the biology of the organisms used in the experiments so that the potential biohazards can be understood and appreciated.

Any research group working with agents that are known or potential biohazards shall have an emergency plan that describes the procedures to be followed if an accident contaminates personnel or the environment. The Principal Investigator shall ensure that everyone in the laboratory is familiar with both the potential hazards of the work and the emergency plan. If a research group is working with a known pathogen for which there is an effective vaccine, the vaccine should be made available to all workers. Serological monitoring, when clearly appropriate, will be provided.

Physical Containment Levels

The objective of physical containment is to confine organisms containing recombinant DNA molecules and to reduce the potential for exposure of the laboratory worker, persons outside of the laboratory, and the environment to organisms containing recombinant DNA molecules. Physical containment is achieved through the use of laboratory practices, containment equipment, and special laboratory design. Emphasis is placed on primary means of physical containment that are provided by laboratory practices and containment equipment. Special laboratory design provides a secondary means of protection against the accidental release of organisms outside the laboratory or to the environment. Special laboratory design is used primarily in facilities in which experiments of moderate to high potential hazard are performed.

Combinations of laboratory practices, containment equipment, and special laboratory design can be made to achieve different levels of physical containment. There are four levels of physical containment, which are designated as BL1, BL2, BL3, and BL4. It should be emphasized that the descriptions and assignments of physical containment detailed below are based on existing approaches to containment of pathogenic organisms. The National Cancer Institute describes three levels for research on oncogenic viruses that roughly correspond to NIH BL2, BL3, and BL4 levels. Currently, the facilities within the biology department contain laboratories that require only BL1 and BL2 practices and physical containment. Hence, only 'standards' that are appropriate to these biosafety levels are detailed in this document.

It is recognized that several different combinations of laboratory practices, containment equipment, and special laboratory design may be appropriate for containment of specific research activities. The selection of alternative methods of primary containment is dependent, however, on the level of biological containment provided by the biological agent used in the experiment. Consideration will be given to other combinations that achieve an equivalent level of containment.

Biosafety Level 1 (BL1)

BL1 Standard Microbiological Practices

- Access to the laboratory is limited or restricted at the discretion of the Principal Investigator when experiments are in progress.
- Work surfaces are decontaminated at least once a day and after work with infectious materials is finished, and after any spill of viable material is cleaned with disinfectants that are effective against the agents of concern.
- All contaminated liquid or solid wastes are decontaminated before disposal as stipulated later in this section (below)
- Mechanical pipetting devices are used; mouth pipetting is prohibited.
- Policies for the safe handling of sharps are instituted. Needles should not be bent, sheared, replaced in the needle sheath or guard, or removed from the syringe following use. The needle and syringe should be promptly placed in a puncture-resistant 'sharps' container and removed as stipulated later in this section (below).
- Eating, drinking, smoking, chewing gum and applying cosmetics are not permitted in the work area. No preparation, storage or consumption of food or drink is permitted in the laboratory.
- Persons wash their hands: (i) after handling materials involving microorganisms and animals (ii) before exiting the laboratory
- All procedures are performed carefully to minimize the creation of splashes or aerosols.
- In the interest of good personal hygiene, facilities (e.g., hand washing sink, shower, and changing room) and protective clothing (e.g., uniforms, laboratory coats) shall be provided appropriate for the risk of exposure to viable organisms containing recombinant DNA molecules.
- A biohazard sign must be posted at the entrance to the laboratory whenever infectious agents are present. The sign must include the name of the agent(s) in use and the name and the phone number of the investigator.

BL1 Special Practices

- Contaminated materials that are to be decontaminated at a site away from the laboratory are placed in a durable leak-proof container that is closed before being removed from the laboratory.
- An insect and rodent control program is in effect.

BL1 Containment Equipment

- Special containment equipment is generally not required for manipulations of agents assigned to BL1.
- Gloves should be worn if the skin on the hands is broken or if a rash is present.
- Protective eyewear should be worn for conduct of procedures in which splashes of microorganisms or other hazardous materials is anticipated. Protective eyewear should not be shared and should remain in the laboratory. If reused or shared, eyewear must be sanitized appropriately.

BL1 Laboratory Facilities

- Laboratories should have doors for access control.
- The laboratory is designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.
- Bench tops are impervious to water and resistant to acids, alkalis, organic solvents, and moderate heat.
- Laboratory furniture is sturdy. All furniture in the laboratory (chairs, stools, etc.) must be nonporous or non-pervious so that it can be cleaned and disinfected in case of a spill. Spaces between benches, cabinets, and equipment are accessible for cleaning.
- Each laboratory contains a sink for hand washing. Foot, knee, or automatically operated sinks are recommended.
- If the laboratory has windows that open, they are fitted with fly screens.

Biosafety Level 2 (BL2)

BL2 Standard Microbiological Practices

- All procedures for BL1 Standard Microbiological Practices, AND

BL2 Special Practices

All BL1 Special Practices, AND

- The Principal Investigator limits access to the laboratory. The Principal Investigator has the final responsibility for assessing each circumstance and determining who may enter or work in the laboratory. For example, persons who are immunocompromised or immunosuppressed may be at increased risk of acquiring infections.
- The Principal Investigator establishes policies and procedures whereby only persons who have been advised of the potential hazard and meet any specific entry

requirements (e.g., immunization) may enter the laboratory or animal rooms.

- When the organisms containing recombinant DNA molecules in use in the laboratory require special provisions for entry (e.g., vaccination), a hazard warning sign incorporating the universal biosafety symbol is posted on the access door to the laboratory work area. The hazard warning sign identifies the agent and the biosafety level, lists the name and telephone number of the Principal Investigator or other responsible person(s), and indicates the special requirement(s) for entering and exiting the laboratory (e.g., immunization, personal protective equipment). Please see last page of this document for an example of an appropriate hazard warning sign.
- Laboratory coats, gowns, smocks, or uniforms are worn while in the laboratory. Before exiting the laboratory for non-laboratory areas (e.g., office, dining hall, library), this protective clothing is removed and left in the laboratory or covered with a clean coat not used in the laboratory.
- Animals not involved in the work being performed are not permitted in the laboratory.
- Special care is taken to avoid skin contamination with organisms containing recombinant DNA molecules; gloves should be worn when handling experimental animals and when skin contact with the agent, contaminated surfaces or equipment is unavoidable. Wearing two pairs of gloves may be appropriate. Gloves are disposed of when overtly contaminated, and removed when work with infectious materials is completed or when the integrity of the glove is compromised. Hands are washed following removal of gloves.
- All wastes from laboratories and animal rooms are appropriately decontaminated before disposal.
- Broken glassware must not be handled directly by hand, but must be removed by mechanical means such as a brush and dustpan, tongs, or forceps. Broken glassware should be promptly placed in a puncture-resistant container and decontaminated if needed.
- Spills and accidents that result in overt exposures to organisms containing recombinant DNA molecules are immediately reported to the Institutional Biosafety Committee. Medical evaluation, surveillance, and treatment are provided as appropriate and written records are maintained.
- Laboratory personnel receive appropriate immunizations or tests for the agents handled or potentially present in the laboratory.
- When appropriate, considering the agent(s) handled, baseline serum samples for laboratory and other at-risk personnel are collected and stored. Additional serum specimens may be collected periodically depending on the agents handled or the function of the facility.

- The Principal Investigator ensures that laboratory and support personnel receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. Personnel receive annual updates or additional training as necessary for procedural or policy changes.

BL2 Containment Equipment

- All BL1 Containment Equipment, AND
- Properly maintained biological safety cabinets (Class I or II), preferably Class II, or other appropriate personal protective or physical containment devices are used whenever:
 1. Procedures with a high potential for creating aerosols are conducted. These may include centrifuging, grinding, blending, vigorous shaking or mixing, sonic disruption, opening containers of materials whose internal pressures may be different from ambient pressures
 2. High concentrations or large volumes of organisms containing recombinant DNA molecules are used. Such materials may be centrifuged in the open laboratory if sealed beads or centrifuge safety cups are used and if they are opened only in a biological safety cabinet.
- A properly maintained biological safety cabinet (Class I or II), will have a current, annual certification that under normal operating circumstances the unit performs to manufacturer's specification.
- Face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials to the face when the microorganisms must be manipulated outside the biological safety cabinet.

BL2 Laboratory Facilities

- All BL1 Laboratory Facility Requirements, AND
- Provide lockable doors for facilities that house restricted agents.
- Install biological safety cabinets in such a manner that fluctuations of the room supply and exhaust air do not cause the biological safety cabinets to operate outside their parameters for containment. Locate biological safety cabinets away from doors, from windows that can be opened, from heavily traveled laboratory areas, and from other potentially disruptive equipment so as to maintain the biological safety cabinets' air flow parameters for containment.

- An eyewash station is readily available.
- Illumination is adequate for all activities, avoiding reflections and glare that could impede vision.
- An autoclave for decontaminating laboratory wastes is available.

Biological Waste Disposal

Potentially hazardous biological/physical waste will be removed (from appropriately labeled containers located in biology department laboratories and appropriately packaged for disposal by JMU biology personnel specially trained in handling of these wastes.

Autoclave Validation

Autoclaves are used to sterilize and decontaminate biological waste. The key components are:

- A. Appropriate use of the autoclave to decontaminate biological waste
 - Minimal parameters are 121°C at 15 psi for 15 minutes.
 - Time may need to be increased for larger loads and larger volumes of liquid.
 - Items should be loaded in manner that ensures that steam can penetrate packages and test tubes.
- B. Recordkeeping – There should be a log or notebook adjacent to the autoclave to indicate:
 - Date
 - Time
 - Use name (and faculty name if student)
 - Cycle type used (liquid, gravity, and vacuum)
 - Items autoclaved (media, waste, etc.)
- C. Performance verification
 1. The autoclave tape should be checked prior to opening the door to ensure all temperature, pressure, and/or time parameters were met.
 2. Autoclave indicator tape should be clearly visible on each item placed in the autoclave.
 3. The autoclave operation should be verified monthly using a biological thermophilic spore former, *Bacillus stearothermophilus*.
- D. Annual calibration and maintenance
 - An outside service vendor will perform this service.

BIOSAFETY IN TEACHING LABORATORIES

The CDC and the National Institute of Health (NIH) have developed standard procedures for working with and providing protection against biological hazards. The publication *Biosafety in*

Microbiological and Biomedical Laboratories (CDC/NIH, 2009)

(<http://www.cdc.gov/biosafety/publications/bmbl5/index.htm>) provides specific descriptions of combinations of microbiological practices, laboratory facilities, and safety equipment associated with four distinct levels of biosafety required for specific categories of infectious agents. Each biosafety level (BSL) is based on the accepted potential hazard of the agent, as well as the general operations of the laboratory. Generally, BSL-1 is for work with agents that pose minimal hazard, while BSL-4 applies to conditions related to protection against agents posing the greatest hazard. Only BSL-1 and BSL-2 are described here. It is important to note that the choice of BSL for a particular organism or laboratory operation is subject to variance based on specific experiments, procedures, culture volumes, or use of mutagenized pathogens involved. Generally, introductory microbiology teaching laboratories are expected to operate under a minimum of BSL-1 standards, while intermediate to advanced instructional or research microbiology laboratories are expected to function under a minimum of BSL-2 guidelines.

BSL-1

BSL-1 is appropriate for instruction or experimentation involving well-characterized agents not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to the environment. Examples of BSL-1 agents include *Bacillus subtilis*, *Lactobacillus* species, *Erwinia* species, *Micrococcus luteus*, *Staphylococcus albus*, and infectious canine hepatitis virus. Students must wear protective laboratory coats (and gloves when appropriate) and wash their hands with soap after they handle viable materials and/or animals, after removing gloves, and before leaving the laboratory. Eating, drinking, chewing gum, handling contact lenses, handling personal electronic devices, and applying cosmetics are not permitted in laboratory work areas. Students at increased risk of infection or who wear contact lenses in laboratories may be instructed to utilize safety glasses, inhalation masks, and/or a face shield as appropriate for the activity at hand. Additionally, mouth pipetting is forbidden; mechanical pipetting devices are required, all procedures are performed carefully to minimize the generation of aerosols, and work surfaces including the instructor's bench are decontaminated at least once a day and after any spill of viable material. If appropriate, students should receive instruction on the safe handling of sharps.

BSL-2

BSL-2 facilities and precautions are required for instruction or experimentation involving agents of moderate potential hazard to personnel and the environment. Examples of BSL-2 agents include *Staphylococcus aureus*, most *Enterobacteriaceae*, *Pseudomonas aeruginosa*, *Clostridium* species, *Mycobacterium leprae*, *Bordetella pertussis*, *Candida albicans*, *Cryptococcus neoformans*, and human blood pathogens such as hepatitis B virus (HBV), HCV, and human immunodeficiency virus (HIV). Many of these organisms are frequently encountered in microbiology laboratory courses. Instructors conducting courses that require BSL-2 must have specific training in handling pathogenic agents and must be directed by supervisors or scientists with advanced experience in this regard. Additional precautions against exposure to BSL-2 agents include (i) limiting laboratory access to specific individuals and to periods of time when instruction or experimentation is ongoing under supervision, (ii) using enhanced precautions against injuries due to contaminated sharps and needle sticks, (iii) substitution of plasticware for glassware whenever feasible, and (iv) conducting procedures representing a high risk of

generating aerosols only within approved biological safety cabinets or the equivalent. Also, eye-wash stations should be readily accessible in the BSL-2 laboratory area.

Students must wear protective laboratory coats while working in the laboratory, and these are to remain in the laboratory (i.e., not worn into areas such as cafeterias, libraries, or administrative offices). In addition, gloves must be worn when handling infected animals or whenever hands may contact infectious materials, contaminated surfaces, or equipment. Double gloving (wearing two pairs of gloves) is appropriate when handling needles or other sharps. Gloves are not reused or worn beyond the laboratory area, and hands are washed whenever gloves are removed. Proper glove removal video is available at www.youtube.com/watch?v=dyLEd9cng5U. Laboratory coats and other protective clothing should be appropriately decontaminated by the institution whenever contaminated or whenever they are to be taken out of the laboratory, such as at the end of a school term.

Individuals at increased risk of infection or for whom infection may be unusually hazardous (e.g., immunocompromised or immunosuppressed individuals) are generally not permitted in the laboratory. To whatever extent practical, the laboratory instructor assesses each situation and advises who may enter or work in the laboratory, and establishes policies and procedures whereby only persons who have been advised of the potential hazard and meet specific entry requirements (e.g., immunization) may enter the laboratory. In the BSL-2 laboratory, when potential pathogens under use necessitate special considerations for entry (e.g., immunization), a hazard warning sign incorporating the universal biohazard symbol should be posted on access doors to the laboratory. The biohazard warning sign identifies the infectious agent, lists the name and telephone number of the laboratory director or other responsible person(s), and indicates any special requirement(s) for entering the laboratory. Further measures may be required for particular cases (e.g., obtaining baseline serum samples and ensuring proper immunization for laboratory personnel and providing specialized training and continuing education on the potential hazards associated with the work involved).

Waste management is similar to that of BSL-1 laboratory. Exposures, spills, or accidents which result in the obvious potential for contamination by infectious agents or toxins must be communicated immediately to the laboratory instructor for appropriate cleanup and medical evaluation. Records are maintained as per institutional guidelines. All cultures and other hazardous waste are either appropriately decontaminated prior to removal from the laboratory or packaged in clearly labeled leak proof containers for contamination elsewhere.

Risk Assessment and Biosafety Levels

The hazards of working with microorganisms must be assessed for appropriate safe handling, containment, and disposal. A risk assessment for each laboratory activity and organism is necessary in order to identify the proper procedures and safety equipment needed. Risk assessment determines the biosafety level of the laboratory. A thorough risk assessment takes into account the microorganism(s) being used, the manipulations performed with the organism(s), and the risks inherent in performing the laboratory activity. The microorganism alone does not determine the biosafety level of the laboratory. Manipulations that generate aerosols, create splash potential, or require large volumes of culture increase the risk associated

with a particular microorganism. Safety requirement information for specific microorganisms may be found at the CDC website (www.cdc.gov/biosafety/publications/BiologicalRiskAssessmentWorksheet.pdf)

Students at Special Risk in Microbiology Teaching Laboratory

Some students may represent special risk considerations in the microbiology laboratory depending on the nature of the organisms handled. Examples of these individuals include:

Immunocompromised or immunosuppressed - those with immune systems rendered deficient through infection (e.g., HIV) or congenital or acquired conditions (e.g., diabetes, complement deficiencies, severe asthma) and/or therapy (e.g., transplant or cancer chemotherapy or long-term steroid treatment). Also at risk are students who live with or care for an immune-compromised individual.

Unvaccinated - those whose personal or religious beliefs or country of origin preclude vaccination against pathogens common in teaching laboratories, such as *B. pertussis*, *Corynebacterium diphtheriae*, and *Haemophilus influenzae*, and *Clostridium tetani*.

Trauma - those students with significant risk of direct contact with pathogens through lesions from surgical procedures, burns, or other injuries or predispositions, such as eczema.

Pregnancy - women who are at an increased risk for some type of infections for themselves and the fetus.

Disabled - students with physical disabilities such as neuromuscular illness (e.g., multiple sclerosis), uncorrected vision impairment (e.g., significant loss of sight or color blindness), or substantial hearing loss.

Training Requirements

In addition to the Biology safety training form, (Standard Laboratory Practices and Safety Rules, Attachment 3), which is completed during safety training session held at the beginning of each semester, each laboratory instructor shall provide instruction on the health risks involved, especially in a BSL2 course / laboratory. The students will be required to review and sign the BIOSAFETY INSTRUCTION AND VERIFICATION form Attachment 4. Students will also receive appropriate training, especially for BSL2 laboratory courses.

XII. Emergency Procedures

Accidents:

Eye contact: promptly flush eyes with water for 15 minutes and seek medical attention. Skin contact: promptly remove any contaminated clothing and flush area with water for 15 minutes.

Seek medical attention if necessary. If medical attention is needed, notify campus security (540-568-6911) to call the rescue squad. Report all accidents/injuries to the laboratory supervisor or the CHO. Complete the “Lab Incident Report” form (<http://www.jmu.edu/biology/safety.shtml>) and submit to the departmental safety officer (Robert Walters, walterrl@jmu.edu).

Fires:

In cases of fires, evacuate the area and activate the manual pull alarm. Call campus security (540-568-6911) to report the fire. Evacuate the building. Only attempt to extinguish the fire if you have been trained, have a clear means of egress, and feel comfortable doing so.

Spills:

Promptly clean up small incidental chemical spills and properly dispose of spilled chemical and cleanup material. Consult *Hazards in the Chemical Laboratory* or *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals* for specific cleanup recommendations.

If the chemical spill is large or if the substance is unknown, flammable, highly volatile, or toxic material or if the spill occurred in an enclosed space, immediately evacuate the area. Call campus security (540-568-6911) to report the spill.

Evacuation:

When the building fire alarm sounds, if you are able to do it safely, turn off all sources of heat, electricity, and gas, and stabilize any reaction processes. Evacuate the building immediately. Evacuate by the stairwell, not the elevator. Supervisors/instructors/research advisers/ faculty should review the evacuation route during safety training.

Laboratory workers should become familiar with evacuation routes before an emergency occurs. In case of emergency evacuation supervisors/instructors/research advisers should arrange a place to meet with students in case of emergency evacuation in the Meadow or near Festival.

XIII. Chemical Procurement, Distribution, Storage & Inventory

Procurement:

Before a chemical is ordered, the person who intends to use it should know the proper handling, storage, and disposal procedures for it. To minimize storage space problems and waste disposal costs, only quantities anticipated for particular experiments planned, or those anticipated for ongoing laboratory courses, should be purchased. The following recommendations from *Prudent Practices in the Laboratory* must be considered:

1. Assessing surplus chemicals prior to ordering new chemicals.
2. Ordering the minimum amount of chemicals necessary.
3. Substituting less hazardous chemicals when feasible.
4. Assessing whether adequate storage space exists for chemicals and any waste that will be produced prior to purchasing chemicals.

All chemicals should be received in Bioscience 1033J. No container should be accepted without an adequate identifying label. The chemical should be added to the chemical inventory system

and an inventory tag placed on the container. This process is performed by the chemical hygiene officer or his designee. The "date received" should be written on the container label by the end user at the time of inspection of the package containing the chemical ordered.

Distribution:

Chemicals that are to be transported from the receiving area should be put onto a cart and transported via the elevator as needed. Highly volatile liquids (such as common lab solvents) and concentrated acids should be transported in appropriate containers that minimize the likelihood of bottle breakage. Items originally taken from appropriate storage area within any laboratory preparation room should be discarded or returned when no longer needed in the laboratory itself.

Storage:

The major quantity of most chemicals should be stored in acid cabinets, flammables cabinets, or in appropriate storage areas in laboratory preparation rooms. Only small quantities of chemicals should be transferred to secondary containers, properly labeled, and stored in the laboratories.

Chemicals should not be stored on bench tops, under hoods, or atop cabinets. Any item-chemical or apparatus-must be stored with a clearance of at least 18 inches from a sprinkler head to allow proper functioning of the sprinkler system. Heavy materials should not be stored on high surfaces or shelves. Exits, passageways, areas under tables or benches, and emergency equipment areas must be free of stored equipment and materials.

- Hazardous chemicals should be segregated in a well-identified area with proper ventilation.
- Chemicals that are highly toxic should be kept in unbreakable secondary containers.
- Stored chemicals should be examined annually for deterioration and container integrity.
- Exposure of chemicals to heat or direct sunlight should be avoided.
- Flammable liquids should be stored in approved flammable liquid storage cabinets.
- Chemical storage areas must be established, so that storing incompatible reagents can be avoided.

Refrigerators used for chemical storage must be labeled "NO FOOD-CHEMICAL STORAGE ONLY." This refrigerator must then be used to store chemicals only. All materials stored inside must be labeled with (1) contents, (2) owner, (3) date of acquisition or preparation, and (4) nature of any potential hazard. **Flammable liquids must not be stored in any laboratory refrigerator unless that appliance is approved for such storage.**

Inventory:

The chemical inventory will contain these data fields:

- Name, as printed on the container
- Molecular formula, for further identification and to provide a simple means of searching

- Chemical Abstract Service (CAS) registry number, for unambiguous identification of chemicals despite the use of different naming conventions
- Source
- Size of container
- Hazard classification, as a guide to safe storage, handling and disposal
- Date of acquisition, to ensure that unstable chemicals are not stored beyond their useful life
- Storage location, in laboratories where multiple locations exist

The chemical hygiene office must receive notification when a chemical container is emptied. The inventory tag number must be included with the notice.

Donation of chemicals or acceptance of donated chemicals

Employees and students are prohibited from donating JMU chemicals. University policy *1506 Property Use (University)* expressly “prohibits using, borrowing, or removing university property for personal or private purposes” which applies to chemicals purchased with university funds. In addition, employees and students are prohibited from accepting donated chemicals. Doing so is an inherently risky practice that creates safety and compliance issues (i.e. labeling, storage, availability of SDS) and exposes the university to significant liability and disposal costs.

XIV. Waste Disposal

The waste disposal program will be maintained by the chemical hygiene officer, who will coordinate the waste disposal protocol for the biology department with the university safety office.

Waste for "commercial" disposal should be put into a suitable container (preferably glass, if possible). A waste label should be filled out and attached to the container. The labeled waste container will be stored in Bioscience 1033J.

- See [Hazards in the Chemical Laboratory](#) or [Prudent Practices for Handling Hazardous Chemicals in Laboratories](#) for specific disposal procedures.
- The university environmental health coordinator will periodically contract with a chemical disposal company to dispose of unwanted and waste chemicals.
- Before a worker's employment ends, chemicals for which that person was responsible should be discarded.

XV. Records

The University Environmental Health Coordinator shall maintain an accurate record of any measurements taken to monitor employee exposures and any medical consultations/examinations including tests or written opinions required by this plan. He/she will assure that such records are kept, transferred and made available in accordance with 29 CFR 1910.20.

XVI. Medical Consultation and Medical Examinations

Laboratory employees who work with hazardous chemicals should be given an opportunity to receive medical attention, including any follow-up examination that the examining physician determines to be necessary, under the following circumstances:

1. Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
2. Where exposure monitoring reveals an exposure level routinely above the action level (or PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirement, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
3. Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

The biology department will work in conjunction with JMU Human Resources to ensure that all medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

The employer should provide the following information to the physician:

1. Identity of the hazardous chemical(s) to which the employee may have been exposed.
2. Description of the conditions under which the exposure occurred including quantitative exposure data, if available.
3. Description of the signs and symptoms of exposure that the employee is experiencing, if any.

For medical consultations required under OSHA Laboratory Standard 29 CFR 1910.1450, the employer shall obtain a written opinion from the examining physician which should include the following:

1. Any recommendation for further medical follow-up.
2. Results of the medical examination and any associated tests.
3. Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace.

XVII. Standard Operation Procedures

A copy of standard operating procedures (SOP's) is to be given to each employee who is involved with any laboratory-based course or research project as part of the safety training. Students should receive an abbreviated version, appropriate for their particular laboratory course. Students and employees must document training for the appropriate SOP's electronically (via web-form found at www.jmu.edu/biology/safety.shtml) or by printed form.

GENERAL GUIDELINES

1. **Responsible behavior in the laboratory is essential.** The dangers of spilled acids and other chemicals, as well as broken glassware created by thoughtless actions, are too great for irresponsible behavior to be tolerated.
2. **Unauthorized experiments should not be performed.** Use only the quantities of reagents as instructed in written procedures, and no more. Consult your instructor if you have any doubts about the instructions in the laboratory manual or written procedure. Prior approval should be obtained from the supervisor/instructor whenever a new laboratory procedure, test or experiment is carried out, or there is a change in an existing procedure, test or experiment. Also, when planning laboratory experiments or procedures involving chemicals, consult this plan to acquire information about specific hazardous substances used in biology laboratories. Additional information concerning all chemicals-as potential hazards, safety issues when handling and disposing of them, and steps to take in case of accidental release (e.g., spill or leak)-is contained in the SDS.. Knowledge of this type of information should be in hand BEFORE the experiment is started.
3. **Working alone in the laboratory is not permitted.** At least one other person should be present in the same room, and an instructor should be readily available.
4. **Think about what you are doing in the laboratory.** Plan ahead. If you give no thought to what you are doing, you predispose yourself to an accident.

LAB APPAREL

1. **Wear appropriate and approved eye protection** - that which meets the requirements of ANSI Z87.1-at all times in all biology laboratories where and when chemicals are handled or there is a possibility of injury to the eyes because of ongoing laboratory procedures (e.g., from projectiles, from boiling water.)
 - a. Eye protection should protect against impact and chemical splashes. Goggles, or other special eye protection, must be worn by those who already wear prescription glasses.

- b. If your eyes come into contact with an acid, alkali, abrasive or otherwise irritating substance, wash your eyes with flowing water from an eyewash station for at least 15 minutes. Seek medical attention immediately.
2. **Footwear that completely covers the feet is required** because of the danger of broken glass and the possibility of chemical spills.
3. **A lab apron or coat should be worn**
 - when working with an open flame
 - when working with and/or transporting hazardous chemicals
4. **Gloves should be worn when working with potential hazards.** These gloves should be made of material known to be resistant to permeation by that chemical. Inspect re-usable gloves before each use, wash them before removal, and replace them periodically.

BIOLOGY LAB POLICIES

1. As part of the **safety orientation** to the laboratory, you will be shown the location of first aid kits, emergency contact numbers, emergency exit, fire extinguishers, eyewash station, safety showers and fire alarms. In addition, you will be informed of the location of SDS, and shown how to use them. All laboratory workers and students should know
 - the hazards of a chemical as stated in the SDS and other appropriate references pertaining to that chemical
 - the location and proper use of emergency equipment
 - how and where to properly store chemicals when not in use
 - the proper method for transporting chemicals within the department
 - the appropriate procedures for emergencies, including evacuation routes, spill cleanup procedures and proper waste disposal
2. **Promptly clean** all chemical spills and **properly dispose** of spilled chemical and cleanup material

3. **Properly label and store all chemicals and equipment.** All chemicals (including solutions and chemicals transferred from their original containers) should be labeled with their names and concentrations.
4. **Do not eat or drink anything, do not chew gum, do not smoke, and do not apply cosmetics** in the laboratory. In addition, since many chemicals are absorbed through the skin, avoid direct skin contact. If you suspect skin contact with chemical substances, such as bottled reagents, wash off these substances with large quantities of water. Wash your hands thoroughly with soap and water before leaving the laboratory. In addition, do not store or handle food or beverages in laboratory areas, including refrigerators used for chemical storage.
5. **Report all injuries to your instructor at once.** Except for very superficial injuries, you will be required to get medical treatment for cuts, burns, or fume inhalation. Complete “Lab Incident Report” form (<http://www.jmu.edu/biology/safety.shtml>) and return to the laboratory supervisor.
6. **Avoid deliberately and directly breathing fumes of any kind.**
 - To test the smell of a vapor, with your instructor's permission, collect some of the vapor in a cupped hand.
 - Work in a chemical fume hood if there is the possibility that noxious or poisonous vapors may be produced.
7. **Do not use mouth suction to fill pipettes** with water or chemical reagents, aqueous or organic. Always use a suction device provided.
8. **Confine long hair and loose clothing** in the lab, since either can catch fire or be chemically contaminated.
9. **Keep your work area neat at all times.** Clean up spills and broken glass immediately. Clutter not only will slow your work, but it leads to accidents. Clean your workspace, including wiping the surface and putting away all chemicals and equipment, at the end of the laboratory preparation, course laboratory period or student project session.
10. **Always carefully and slowly pour** acids into water when mixing to avoid spattering.
11. **Discuss with the instructor the disposal** of excess reagents. Dispose of solids in approved containers. **DO NOT RETURN REAGENTS TO THEIR ORIGINAL CONTAINERS.**
12. Do not block access to emergency equipment or exits.
13. All chemicals and wastes should be placed in their proper storage area at the end of the day.
14. All working surfaces and floors should be cleaned regularly.

15. Glassware:

- Do not use broken, chipped, starred or cracked glassware.
- Clean all glassware after use.
- Do not pick up broken glassware with bare hands. Use gloves or sweep it up. Deposit broken glass in a "Broken Glass Safety Toss Box."
- Handle hot glassware with proper size and type of tongs or hot mitts.

16. Vacuum and pressurizing equipment and materials:

- Use a safety shield whenever an implosion might occur when working with vacuum equipment. Shield or wrap Dewar flasks or other evacuated glass apparatus.
- Relieve vacuum in all parts of system before opening apparatus. Relieve vacuum slowly. Avoid sudden pressure changes which could cause breakage or spattering of contents. Do not relieve vacuum on heated apparatus until apparatus has cooled.
- Use a safety shield whenever an explosion might occur when working with pressurizing equipment.
- Do not apply pressure to standard glassware.
- Vent pressure in all parts of the system before opening.

17. Compressed gases:

- Store and transport compressed gas cylinders with the safety caps on.
- Transport large cylinders on a hand truck to which the cylinder is secured.
- Cylinders should be clamped securely to a wall or other firm support with an appropriate cylinder clamp or chains.
- Always use a reducing valve with gas cylinders.
- Do not lubricate, modify or tamper with a cylinder valve.
- Do not heat cylinders or store them near a heat source.

18. Syringes needles and other sharps:

Syringes are intended for dispensing reactive and/or hazardous chemicals that cannot be safely handled in any other manner. Following use, syringes needles are to be placed intact in a puncture-resistant, leak-proof container specified for sharps disposal. Syringes should be re-capped and/or stored for repetitive use.

XVIII. Equipment Safety

At the start of the introductory section pertaining to "Laboratory Equipment" in Prudent Practices (2011) is this statement: "Proper use of laboratory equipment is required to work safely with hazardous chemicals. Maintenance and regular inspection of laboratory equipment are an essential part of this activity. Many of the accidents that occur in the laboratory can be attributed to improper use or maintenance of laboratory equipment."

Requirements and recommendations concerning safety with equipment commonly located in chemical laboratories appear below.

Water-cooled equipment (e.g., distillation apparatus):

The major problem with cooling water is localized flooding due to the disconnection of tubing supplying water to the condenser. Tubing connections should be checked frequently, and the entire apparatus should be operated only when the laboratory is occupied

Electrically-powered equipment (including fluid and vacuum pumps, lasers, power supplies, both electrophoresis and electrochemical apparatus, stirrers, hot plates, water baths, heating mantles, microwave ovens and ultrasonicators):

The major hazard is electrical, as a shock hazard and as a source for ignition of flammable or explosive vapors.

All repair and calibration work must be carried out by properly trained and qualified personnel. Before modification, installation, or even minor repairs of electrical equipment are carried out, the devices must be de-energized, and all capacitors, discharged safely.

All 110-volt (V) outlet receptacles should be of the standard design that accepts a three-prong plug and provides a ground connection. **The use of two-pronged adapters to connect equipment with three-pronged grounded plugs to two-wire outlets is prohibited.** Ground fault circuit interrupter circuits should be located where appropriate, i.e., receptacles less than 6 feet from sinks.

Receptacles that provide electric power for operations in fume hoods should be located outside the fume hood, which prevents the production of electric sparks inside the hood. In addition, cords should not dangle outside the hood in such a way that they accidentally can be pulled out of their receptacles or tripped over.

General precautions for working with electrical equipment:

1. All equipment must be insulated properly. During equipment use, if frayed or damaged cords are found, they must be replaced before further use of the equipment is permitted.

The complete electrical isolation of electrical equipment and power supplies must be ensured to prevent the possibility of accidental contact with electrical circuits.

2. The isolation of electrical equipment which may generate sparks from volatile solvents must be ensured.
3. To minimize the possibility of electrical shock, adequate grounding will be provided for all electrical equipment.
4. Pieces of equipment should be unplugged prior to adjusting, modifying or repairing them. If it is necessary to power this equipment, hands must be dry and, if feasible, nonconductive gloves and shoes with insulated soles should be worn.
5. Lab supervisors must be made aware of the location and operation of power shutoffs for areas in which they work.

Personal safety techniques for use with electrical equipment:

1. Contact with energized electrical circuits must be avoided. Electrical equipment should be serviced by only qualified individuals, and only after power has been disrupted and capacitors are discharged. Before electrical equipment is reconnected to power after servicing, it must be tested to ensure proper grounding.
2. If a circuit breaker "trips," steps must be taken to assure that the overload or short-circuit which caused the failure is corrected.
3. Ground-fault circuit interrupters must be in place where required.

XIX. Electrical equipment used in BIOLOGY laboratories requiring special precautions:

Ultrasonicators:

When ultrasonic equipment is operated in the laboratory, appropriate ear protection must be worn and/or the apparatus must be enclosed in a 2-cm-thick wooden box or in a box lined with acoustically absorbing foam or tiles to substantially reduce acoustic emissions.

Direct contact of the body with liquids or solids subjected to high-intensity ultrasound should be avoided.

Centrifuges:

Centrifuges should be properly installed and must be operated by only trained personnel.

The load must be balanced each time the centrifuge is used, and the lid must be closed while the rotor is moving. The centrifuge must have an interlock to ensure that the lid cannot be opened with the rotor moving.

Electrical Instruments and Appliances (e.g., circuit testing equipment, electrophoresis power supplies, microscopes, ovens, water baths, hot plates and stirring devices, top-loading and

analytical balances, microwave ovens, pH and specific ion meters, vacuum pumps, refrigerators and freezers):

- For all equipment, a chassis ground must be in place.
- Special precautions should be taken to avoid the possibility that water or other chemicals could be spilled onto these instruments.
- Only qualified individuals should make repairs.

Electromagnetic Radiation Hazards (e.g., UV sources, lasers, microwave sources)

- Overexposure to UV light, direct or reflected, should be minimized. Lamp sources should be sealed or enclosed whenever possible, and appropriate eye protection and/or face shields should be worn. Long-sleeved clothing and gloves should be worn to protect arms and hands.
- Microwave sources must be operated only with appropriate microwave generator shielding in place. Avoid metal in microwave ovens, since arcing may occur, causing the ignition of any solvents present. Since superheating of liquids can occur, capping of vials and other containers can result in explosion from pressure buildup within the vial. Use only selected plastic containers that will resist melting.

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