UNIVERSITY of NEW HAMPSHIRE

Laboratory Safety Plan

Revised:
June 7, 2007

The most current version of this document can be found at:
http://www.unh.edu/ehs

EMERGENCY INFORMATION

POST AT THE NEAREST PHONE

	HOME PHONE	OFFICE PHONE
PRINCIPAL INVESTIGATOR:		
ALTERNATE CONTACT:		
LOCATION OF CHEMICAL SPILL KIT:		
LOCATION OF BIOLOGICAL SPILL KIT:		
LOCATION OF FIRE EXTINGUISHER:		
LOCATION OF FIRE ALARM:		

	CELL PHONE	OFFICE PHONE
Director of EHS *Primary Emergency Coordinator*	(603) 534-9871	(603) 862-4041
Hazardous Waste Coordinator *Alternate Emergency Coordinator*	(603) 534-9873	(603) 862-3526
Manager of Laboratory and Environmental Safety *Alternate Emergency Coordinator*	(603) 312-2540	(603) 862-4041
Radiation Safety Officer *Alternate Emergency Coordinator*	(603) 312-2500	(603) 862-3607
Laboratory Safety Officer	(603) 534-9872	(603) 862-5038
Hazardous Waste Specialist	(603) 534-6010	(603) 862-0683
Occupational Safety Coordinator	(603) 828-5323	(603) 862-4761
Environmental Systems Technologist		(603) 862-1510
Maintenance Control Center		(603) 862-1437
Environmental Health and Safety		(603) 862-4041
Fire/Police Dispatch		911
Emergency Medical Services (EMS), Hospital, etc.		911
Local Emergency Response Team		911
State of New Hampshire - Department of Environmental Services		(603) 271-2942

This document must remain visible – DO NOT COVER!

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F O R E W O R D

The **Laboratory Safety Plan** is intended to comply with the following federal, state and local regulations:

- USNH USY VI.F.3. "University System Policy on Environmental Health and Safety"
- USNH BOT VI.F.3. "Board of Trustee Policy on Environmental Health and Safety"
- New Hampshire RSA 277-A "Worker's Right to Know Law"
- New Hampshire Lab 1403.36 "Hazardous and Toxic Substances"
- 59 CFR 34496 "Guidelines for Research Involving Recombinant DNA Molecules"
- 29 CFR 1910.1450 "Occupational Exposures to Hazardous Chemicals in Laboratories"
- 29 CFR 1910.1200 "Hazard Communication"
- Durham ordinances

The **Laboratory Safety Plan** should not be considered the only reference for health and safety concerns. However, this document does provide a compilation of suggested work practices, protocols and systems to work safely in University of New Hampshire laboratories. In addition, the Office of Environmental Health and Safety is always available to address health and safety concerns. This document will be evaluated and updated at least annually by the Institutional Biosafety Committee and the Chemical Safety Committee. This document also contains several appendices with essential information for laboratory personnel. These appendices are not considered part of the **Laboratory Safety Plan** as they are always changing or evolving. The appendices will be evaluated by the Office of Environmental Health and Safety on a routine basis.

At the time of publishing, the Chemical Safety Committee and the Institutional Biosafety Committee were composed of the following individuals:

Chemical Safety Committee
Bradford Manning, Chair
Clyde Denis
David Gillum
Erik Hobbie
Manya Hult
Sarah Kenick
Robert Mair
VK Mathur
Marty McCrone
Vasiliki Partinoudi
Janet Poff
Julie Simpson
Cheryl Whistler
Charles Zercher

Institutional Biosafety Committee
Aaron Margolin, Chair
John Collins
Lorraine Doucet
Kevin Gardner
Robert Gibson
David Gillum
Michael Lesser
Bradford Manning
Subhash Minocha
Susan O'Connor
Kathy Schusler
David Shay
Julie Simpson
Joyce Stone
Roger Wells

The Chemical Safety Committee and the Institutional Biosafety Committee would like to thank the University of Massachusetts for allowing us to use their template for this health and safety manual.

Chapter 1 – Laboratory Safety Plan

Section 1: Introduction

Section 2: Administrative Responsibilities

Department Chairs
Departmental Health & Safety Coordinator
Faculty Members
Employees and Students
Environmental Health & Safety

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Section 1: Introduction

It is the policy of UNH to maintain a safe environment for its students, academic appointees, staff and visitors in an atmosphere that encourages employees, students and other campus members to communicate occupational safety and environmental health matters without fear of reprisal. The University will promote comprehensive biological and chemical safety programs based on applicable health and safety standards promulgated by Federal and State agencies, including the OSHA regulation, 29 CFR 1910.1450, titled, "*Occupational Exposures to Hazardous Chemicals in Laboratories*," as well as published standards of nationally recognized professional health and safety groups.

The Office of Environmental Health and Safety (OEHS) and the various campus safety committees help to assure that campus policies and state and federal mandates are followed. OEHS and the safety committees have written the Laboratory Safety Plan to define administrative responsibilities, accepted safety guidelines and standards, proper laboratory facilities, safety equipment, emergency procedures, medical surveillance, exposure monitoring, training and recordkeeping requirements.

The purpose of the Laboratory Safety Plan is to provide a framework for recognizing, evaluating and controlling hazards associated with laboratory operations. Departments may choose to go "above and beyond" this document and implement additional health and safety protocols. Implementation of the Laboratory Safety Plan depends on the cooperation of department chairs, faculty, laboratory staff, students, OEHS staff and members of safety committees. The responsibility for safety and health must be shared by all and we must work towards meeting the standards set forth in this Laboratory Safety Plan with the common goal of promoting a healthy and safe environment for all employees and students. We recognize that in some situations, proper facilities and equipment are not available for conducting projects. When this is the case, faculty members should consult with the *Biological/Chemical Safety Committee Representative* or OEHS for assistance in evaluating hazards and finding ways to conduct work in a safe and healthy manner.

J. Bonnie Newman
Interim President

Section 2: Administrative Responsibilities

Each individual faculty member is responsible for implementing all University health and safety policies in his/her laboratory. The Dean of each college will implement University health and safety policies. The Department Chair will ensure compliance with existing health and safety policies by designating a *Biological/Chemical Safety Committee Representative*. OEHS is available to provide additional oversight, training, consultation and technical assistance. Specific responsibilities are outlined below.

Responsibilities of Department Chairs

1. Disseminate and inform faculty and staff of University health and safety policies.
2. Designate a biological/chemical safety committee representative.
3. Ensure faculty and staff have updated their emergency contact lists and communicated that information to the Office of Environmental Health and Safety.

Responsibilities of the Biological/Chemical Safety Committee Representative

1. Assist each faculty member in implementing University safety and health policies.
2. Communicate information on health and safety policies to faculty and staff.

Responsibilities of Faculty Members

1. Implement all applicable health and safety policies in the laboratory.
2. Develop written safety procedures applicable to their research and workers.
3. Mandate laboratory practices and engineering controls that reduce the potential for exposure to hazards.
4. Inform all laboratory staff and students of the potential hazards associated with laboratory operations. Discuss the hazardous properties associated with chemicals in the laboratory (e.g. reproductive toxin, carcinogen, mutagen, poison, flammable, peroxidizable, explosive).
5. Inform all laboratory personnel of the proper procedures for dealing with accidents and spills.
6. Ensure employees and students are trained as required by the **State of New Hampshire RSA 277-A** regulation, the **OSHA Right to Know Law and** University of New Hampshire health and safety policies.
7. Supervise laboratory personnel to ensure that safe practices and engineering controls are employed.
8. Instruct laboratory personnel on the location and use of all safety equipment in the facility.
9. Designate at least one person to serve as a safety contact in your absence.
10. Post telephone numbers for all emergency response and safety contacts in a noticeable area in the laboratory, preferably near a telephone. Ensure the posting is updated during sabbaticals or other absences.
11. Keep all emergency telephone call-back lists up-to-date.
12. Report accidents and any other safety problems to the *Biological/Chemical Safety Committee Representative* and OEHS.
13. Address issues identified by the Laboratory Safety Survey (see **Appendix E**).

14. Ensure that pertinent material safety data sheets (MSDS) are available. OEHS provides online MSDS at http://www.cems.sr.unh.edu.

Responsibilities of Employees and Students

1. Follow all safety and health procedures specified in the Laboratory Safety Plan and by the faculty supervisor in the laboratory.
2. Complete required health and safety training sessions.
3. Report accidents, unhealthy and unsafe conditions to the faculty supervisor, *Biological/Chemical Safety Committee Representative* and/or OEHS.
4. Notify the faculty supervisor of any health conditions that could lead to serious health situations in the laboratory.

Responsibilities of the Office of Environmental Health & Safety (OEHS)

1. Provide technical guidance on matters of laboratory safety.
2. Inspect laboratories to assure compliance with safety and health guidelines and regulations and to assist with remediation of safety issues.*
3. Investigate accidents and recommend action to reduce the potential for recurrence.**
4. Coordinate clean-up operations in the event of a large chemical or biological spill or if a spill reaches the environment.
5. Develop and conduct training programs in laboratory safety.
6. Work with state and local officials on matters of codes and enforcement.
7. Assist laboratory personnel with evaluating, preventing and controlling hazards.
8. Oversee the adoption and implementation of all University health and safety policies.
9. Maintain training and audit documentation.

* OEHS will make every attempt to schedule laboratory audits with faculty members. However, if the faculty member is unavailable or is unresponsive, OEHS will proceed with the safety audit.

** OEHS may conduct unannounced accident investigations. Please be aware that federal, state and local inspectors may also conduct unannounced inspections.

Section 3: Safety Committees

UNH has established a Radiation Safety Committee (RSC) and the Institutional Biosafety Committee (IBC) according to government mandates. UNH has also established a Chemical Safety Committee (CSC) and an Occupational Safety Committee (OSC). The members of these safety committees are appointed by the Vice President for Research and Public Service to improve conditions specific to this University. It shall be the responsibility of these committees to establish safety and health policies in accordance with federal, state and local regulations and evaluate research being conducted on the UNH campus for safety and health considerations.

Section 4: Laboratory Construction and Renovation Projects

All design, construction and/or modification of laboratory facilities must be reviewed by the Facilities Services and OEHS, whether executed by an outside contractor or internal personnel. In order to ensure the safety of new and renovated laboratories, specific design and construction features are required by state and federal codes.

Chapter 2 – Laboratory Practices & Safety Equipment

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Section 4: Laboratory Safety Survey

Section 1: General Laboratory Safety Procedures

1. Know the hazardous properties of the materials you are working with (e.g. chemical, biological, electrical, radioactive): Refer to the 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.
2. Know the location of safety equipment and emergency and exit procedures.
3. Always wear appropriate clothing (e.g. pants, shirts, shoes) and personal protective equipment (e.g. safety glasses, lab coats, gloves) in the laboratory. Open sandals, clogs, crocs, and similar footwear are prohibited; shorts and skirts are not recommended.
4. Remove personal protective equipment (PPE) before leaving the laboratory.
5. Do not work alone in the laboratory at any time. When hazardous operations are conducted, arrangements should be made to have another person present in the lab.
6. Use a properly operating fume hood when working with hazardous chemicals.
7. Do not eat, smoke, drink, prepare food or apply cosmetics in the laboratory.
8. Keep work areas clean and uncluttered at all times.
9. Do not leave reactions unattended. Contact OEHS for more information.
10. Unauthorized individuals are prohibited from entering the laboratory.
11. Persons under 14 years of age are prohibited from entering certain high-hazard/high-risk areas (e.g. laboratories with hazardous chemicals, infectious organisms, or rooms with hydraulic equipment, lasers or radioactive material). Exceptions to this policy require prior written approval from OEHS. Additional information about children in high hazard areas can be found on the OEHS website at http://www.unh.edu/ehs/pdf/UNH_CIHHA.pdf.
12. Persons under 16 years of age are prohibited from entering any Biological Safety Level (BSL-3) laboratories.
13. Employees under 18 years of age are subject to the New Hampshire Youth Employment Law (RSA 276-A). Contact Human Resources for more information.
14. Non-laboratory and non-assistance animals are not allowed in campus buildings.
15. Refer to ***Safety in Academic Chemistry Labs*** (ISBN: 0841232598) and ***Biosafety in Microbiological and Biomedical Laboratories*** (ISBN: 017-040-00547-4) at http://www.cdc.gov/od/ohs/biosfty/bmbl4/bmbl4toc.htm in addition to this manual for other safety procedures to follow in the laboratory.

Section 2: Security

Laboratory security is an integral part of an effective safety program. Follow these steps to ensure a secure working environment in your laboratory:

1. Keep laboratory doors closed and locked when unoccupied.
2. Keep stocks of organisms and hazardous chemicals locked when the laboratory is unoccupied.
3. Keep an accurate record of chemicals, stocks, cultures, project materials, growth media, and those items that support project activities.
4. Notify UNH police if materials are damaged or missing from laboratories.

5. Inspect all packages arriving into the laboratory.
6. When research is completed for the day, ensure that chemicals and biological materials have been stored properly and securely.
7. 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.
8. Discuss other security-specific requirements with your supervisor and colleagues.

Section 3: Laboratory Design and Equipment

The following safety devices/equipment should be available for laboratory personnel working with hazardous materials.

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.

At least three feet of space in each direction is required beneath the shower and this area must be kept free of all obstacles. Facilities Services inspects drench showers annually for proper flow and operation. A "DO NOT USE" notice is placed on the unit if the shower is not properly functioning.

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 installed on the same level as the hazard (accessing the equipment should not require going up or down stairs or ramps). In addition, the path of travel from the hazard to the equipment should be free of obstructions and as straight as possible.

3. Fire Extinguishers

Fire extinguishers are placed in or just outside laboratories depending on the hazards. A dry chemical (BC, ABC) type extinguisher is located in laboratory facilities where flammable liquids are used and a carbon dioxide (CO_2) type extinguisher is located in laboratories with computer and electrical equipment (i.e.

mass spectrometers, gas chromatographs and NMR facilities). Metal-X extinguishing agent, a graphite material, is used to smother a Class D (flammable solids) fire and is distributed to laboratories when appropriate. The Durham Fire Department requires training before using a fire extinguisher. For more information about fire extinguishers, contact OEHS.

4. 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:

Item and Minimum Size or Volume*	Minimum Quantity
Absorbent compress, 32 square inches (No side smaller than 4")	1
Adhesive bandages, 1" x 3"	16
Adhesive tape, 5 yards	1
Antiseptic, 0.5 gram application	10
Ice packs	2
Medical exam gloves (disposable)	2 pair
Sterile pads, 3" x 3"	4
Triangular bandage, 40" x 40" x 56"	1

***** *Other items as needed.*

These kits should *not* have topical creams, liquids or ointments that can cause further discomfort and/or hinder medical treatment.

5. Laboratory Safety Information

MSDS, emergency procedures, safety manuals and other references should be readily available for all laboratory personnel. For additional resources, see the UNHCEMS™ web site at http://www.cems.sr.unh.edu.

6. Door Postings and Other Signs

A hazard and emergency information sign should be posted on the laboratory door exterior, facing the corridor. This sign is used by *emergency response personnel*. The sign identifies hazards within the facility, the responsible faculty member and other persons to be contacted in the event of an emergency. In the event of an accident, chemical spill, fire or personal injury, assistance from a person familiar with the laboratory may be requested. OEHS should be consulted about other door postings and signs (e.g. radioactive materials, biohazards) that may be required. Signs should be reviewed by the faculty member at least annually or in the event that pertinent information changes. Contact OEHS at 862-4041 to request a new sign.

7. Open Floor Drains and Sink Traps

In order to reduce odors in buildings, sink traps and floor drains should be filled weekly with one to two liters of water. Laboratories that are not used for long periods of time should be checked regularly to assure that floor drains and sink

traps are filled. No equipment should be placed over floor drains to obstruct this routine maintenance.

8. Sharp Containers and Glass Only Boxes

Sharps containers are used for the disposal of hypodermic needles and syringes, razor blades and other sharp items. When three-quarters (¾) full, sharps containers should be sealed, labeled with the building/room number, placed into a biohazard bag and then placed into a biological or infectious waste burn box. Call OEHS at 862-4041 for disposal instructions. See **Appendix F** for additional information.

"Glass Only" boxes are used for the disposal of "clean" broken glass only. When three-quarters (¾) full, the boxes should be properly sealed, labeled with the building/room number and disposed in a dumpster. "Sharps Containers" and "Glass Only" boxes can be obtained (depending on the building) from the chemical stockroom or departmental offices.

9. Mechanical Pipetting Aids

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

10. Vacuum Line Filtration

To prevent fluid and aerosol contamination of the central vacuum system in certain buildings, it is recommended that a high-efficiency particulate air (HEPA) filter cartridge be placed in any suction tubing immediately before the vacuum inlet (valves). This will help protect the central vacuum system from corrosion, rust, etc. These filters should be replaced annually or whenever there is evidence of filter blockage, failure or wetness.

11. Placement of Safety Equipment

In newly constructed and renovated laboratories, drench showers, eye washes and fire extinguishers are 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 egress from the room. In addition to the aforementioned safety equipment, emergency gas shut-offs and electric panels should also be located next to the main door. Depending on the work, additional controls and equipment may be needed for protection of laboratory workers.

12. Laboratory Vision Panel

The Laboratory Vision Panel is the window space in the main door of the laboratory, used by emergency response personnel to identify internal problems (e.g. an injured person, a small fire, a chemical spill). The Durham Fire Department requests that the vision panel in the door not be blocked, unless it is necessary to maintain darkness for optical work, spectroscopy or photography. The Laboratory

Vision Panel should be a 100 square-inch wire glass window panel in the door to the laboratory.

Section 4: Laboratory Safety Surveys

OEHS inspects laboratories at least once a year. The safety inspection includes fume hood operation, laboratory techniques, emergency and safety equipment, chemical storage, electrical safety and general housekeeping. Additional safety surveys are conducted when radioactive materials and biohazardous materials are in use and hazardous waste is stored. OEHS also inspects buildings and fire protection equipment to assure compliance with all appropriate state building and fire prevention codes.

Following the laboratory safety survey, a report listing the hazard(s) is sent to the faculty member responsible for the laboratory. The faculty member is responsible for correcting the operational hazards. (UNH is responsible for correcting all infrastructure deficiencies.) If the faculty member fails to correct the hazard, a second notice is sent to the department head and the *biological/chemical safety committee representative*, with a copy to the faculty member. Follow-up surveys are conducted in laboratories with extremely hazardous conditions and/or numerous violations.

In addition to these annual laboratory safety surveys, it is recommended that laboratory personnel update the chemical inventory and periodically conduct their own safety inspections.

Chapter 3 – Personal Protective Equipment

Section 1: Personal Protective Equipment Policy

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

Personal protective equipment is not supplied by OEHS. However, OEHS will assist with recommendations on specific types and uses of protective equipment.

Section 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, biohazardous materials, aerosolized material, flying objects.). Please note that all protective eye and face wear should meet ANSI Z87.1-1998 and ANSI Z136.1-2000 standards. Visitors' safety glasses are **not** acceptable for any laboratory procedures. Contact OEHS at 862-4041 for additional information.

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. 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. The University has an agreement with a local optician to provide low-cost regular or prescription safety glasses. Be sure to specify side shields. For authorization forms or additional information, contact Human Resources.

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 may also be required for work with UV light, lasers (see **Chapter 12 – Laser Safety**) and other types of radiation, which is absorbed by the eyes or skin (chemical splash goggles are not adequate for these types of work). Please consult with the Radiation Safety Officer (RSO) or Laser Safety Officer (LSO) by calling OEHS at 862-4041.

Section 3: Laboratory Coats, Gloves and Other Protective Clothing

Laboratory coats and shoes must be worn when performing laboratory work **(open toed-shoes, sandals, flip-flops, clogs, crocs, 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. 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, latex, vinyl, or nitrile gloves, popular for their dexterity, are not appropriate for highly toxic chemicals or solvents. When using chemicals, consult the chemical compatibility information that is provided in the Material Safety Data Sheet (MSDS) and manufacturer's catalogs to help select proper personal protective equipment, including gloves and respirators. More information on specific types and uses of personal protective apparel is available from OEHS.

Section 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. However, in some isolated instances it has proven necessary to provide respirators to individuals. In these cases, the procedures outlined in the **UNH Respiratory Protection Program** must be followed.

Section 5: Protective Clothing beyond the Laboratory

University Policy requires the use of appropriate gloves, safety glasses, lab coats, and other personal protective equipment within the laboratory. The following guidelines state that all contaminated, potentially contaminated, or the perception of potentially contaminated protective clothing and equipment beyond the lab 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.

- 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 (i.e., biological, chemical, radiological) materials on public roads.

Section 6: Laundering Laboratory Clothing

Contaminated clothing (including laboratory coats and gowns) with mild chemical or biological contamination should be laundered separately from other clothes using one of the following methods:

1. UNH Laundry Facilities

Laundry facilities exist in a few departments at UNH. Follow departmental procedures for cleaning contaminated clothing. Generally, these facilities are for intra-department use only.

2. Professional Laundering

A professional service company may be used if your department does not have the capability to wash contaminated clothing. It is your responsibility to determine if the cleaning company is capable and willing to launder your contaminated clothes.

3. Personal Laundering

Clothing contaminated with biohazardous material must be autoclaved prior to laundering at home. NOTE: Personal laundering is not acceptable for chemically-contaminated clothing.

Warning

- Clothing that is overtly contaminated with chemicals must be disposed as hazardous waste.
- Clothing contaminated with radiological material must be disposed as radiological waste.

Chapter 4 – Ventilation

Section 1: Laboratory Ventilation Policy

All work with hazardous materials must be conducted in the appropriate fume hood, gas cabinet, glovebox or biological safety cabinet.

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 chemical fume hood, gas cabinet or glovebox. In special situations, vacuum systems are acceptable if approved by the Department Chair and OEHS. ***Ductless fume hoods are not acceptable.*** Chemical fume hoods and other specialty ventilation devices must be located away from supply air (air conditioners, ducts), doors and other openings that interfere with their operation. In addition, the exhaust stacks (on the roof) must have ductwork that extends at least ten feet above the roof line. (See the **UNH Fume Hood Program** on the OEHS website for additional information.)

Certain biological agents, such as *Bacillus anthracis, Mycobacterium tuberculosis, Salmonella typhimurium,* HIV and Hepatitis B, may only be used in certified biological safety cabinets. When it is not possible to meet the above requirements, OEHS and the Department Chair must evaluate hazards together with the faculty member to determine if work can be conducted safely.

Section 2: Fume Hoods

Fume hoods are checked annually by OEHS. 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 chemical fume hood. Variable air volume (VAV) hoods maintain a constant face velocity at different sash heights. Researchers should close the sash as much as possible when conducting experiments.

Hoods that do not meet the minimum exhaust requirements during OEHS inspections are posted with "DO NOT USE" notes and Facilities Maintenance is notified about the need for repairs. Once repairs have been made, OEHS will test the fume hood for proper operation. Refer to the **UNH Fume Hood Program** for more detailed information regarding fume hoods.

1. Procedures for Proper Use of Fume Hoods

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

a. Ensure that air is entering the unit.
b. Ensure the baffle openings are not blocked and air is flowing properly.
c. Conduct work at least six inches from the edge of the hood.
d. Lower the sash to protect yourself from dangerous reactions.
e. Keep hood clean and uncluttered. Wipe up spills immediately.

f. Be aware that drafts from open windows, open doors, fans, air conditioners, high traffic walkways may interfere with normal hood exhaust.
g. Use perchloric acid only in a special perchloric acid hood. (See **Perchloric Acid Hoods** below and consult OEHS regarding perchloric acid use.)

2. Fume Hood Alarms

Fume hood alarms indicate substandard operation of fume hoods. They are installed on every new fume hood system and on those which have been upgraded. 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 Facilities Services. Do not use the fume hood, until repairs have been made and OEHS has removed the "Do Not Use" sign.

3. Perchloric Acid Hoods

Regular fume hoods must never be used for perchloric acid. Special perchloric acid hoods must be used. The hood must be labeled clearly and used only for perchloric acid or other mineral acids, such as nitric, hydrochloric and hydrofluoric. No organic solvents should be stored or used in a perchloric acid hood. When perchloric acid is heated above ambient temperature, vapor is formed which can condense in the ductwork and form explosive perchlorates. The hood and ductwork should be washed down after each use.

Section 3: Glove Boxes

Glove boxes can be used for work with particularly hazardous substances including select carcinogens, reproductive toxins, air reactive chemicals and substances which have a high degree of acute or chronic toxicity. When correctly used, these units prevent vapors, gases and particulates from escaping into the laboratory.

Section 4: Gas Exhaust Cabinets

Toxic and flammable gases such as arsine, phosphine, silane, hydrogen chloride, ammonia, hydrogen phosgene, selenide and nickel carbonyl should be used and stored in an approved gas storage cabinet. In a gas cabinet hazardous gases are vented through a scrubbing system, which allows inert gases to be exhausted to the atmosphere. In addition, gas cabinets are equipped with monitoring devices and alarm systems that sense hazardous conditions, warn employees of a malfunction and automatically shut-off the gas flow.

Section 5: Biological Safety Cabinets

Class II (vertical laminar flow) biological safety cabinets (BSC) provide a partial containment system for the safe handling of pathogenic microorganisms. 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 of BSCs must be conducted annually and during the interim if the cabinet is moved or if a problem is suspected. The University maintains a contract with a company to service and to certify BSCs. Certification information is available by calling OEHS.

The following rules apply to biological safety cabinets:

1. BSC is certified annually by an outside company.
2. BSC is decontaminated frequently and after work is complete.
3. Gas lines are prohibited in a re-circulating BSC.
4. Open flames are prohibited inside the BSC.
5. Toxic chemicals are prohibited inside the BSC.
6. Ultraviolet lights are routinely checked and replaced as needed.

Section 6: Laminar Flow Hoods

Laminar flow hoods are present in a number of laboratory facilities. These clean benches provide a very clean environment but must be used only for the manipulation of non-hazardous materials. Since the operator sits in the downstream exhaust from the clean bench, this equipment must never be used for the handling of toxic, infectious or sensitizing materials, including volatile chemicals, cell culture materials (except plant cell cultures) or drug formulations.

Chapter 5 – Emergencies & Accidents

Section 1: Emergency Assistance

Dial 911 to request emergency assistance (fire, police or ambulance) on campus. In all emergencies and accidents, the first consideration is your safety and the safety of those around you. See the **UNH Emergency Procedures Program** for more information.

Section 2: Preparation

In order to be prepared for an emergency, know the hazards of each compound you work with. Assess the risks before using any chemical and have a laboratory emergency plan for all procedures with hazardous materials on file and posted in a conspicuous area for employees and emergency responders. Consider the following criteria before working with any hazardous agent:

- Toxicity, reactivity and flammability of the compound.
- The amounts involved.
- The expected duration of your exposure to the compound.
- Potential routes of entry for the chemical (i.e. inhalation, ingestion, injection, skin contact).

Refer to the UNH Chemical and Environmental Management System (UNHCEMS™) website for additional information: http://www.cems.sr.unh.edu.

Section 3: Chemical Spills

In the event of a chemical spill:

1. Alert all persons nearby.
2. If you understand the properties of the chemical and know it to be a minimal hazard and the amount spilled is small, clean it up. Properly package and label as hazardous waste. Complete this step only if it is safe to do so.

Otherwise,

3. Avoid breathing vapors of the spilled material.
4. If flammables are spilled and your safety is assured, turn off any ignition devices.
5. Evacuate the area and close the door to the laboratory facility.
6. Immediately notify your supervisor of the incident.
7. During regular work hours (Monday through Friday, 8 a.m. to 5 p.m.), contact OEHS at 862-4041. On weekends, holidays and after 5 p.m., contact UNH Police at 911 for advice and assistance. Be prepared to provide the identity, amount and location of the spill, as well as your location and a phone number where you can be reached (not your lab phone, since you should not remain in the lab after the spill).

Section 4: Mercury Spills

Mercury has been typically found at the University of New Hampshire in thermometers, thermostats, and certain laboratory devices. From time to time accidents may occur which require the clean-up of liquid mercury.

Mercury Spill Kits

Rooms containing liquid mercury or mercury-containing devices must have a special spill kit present. At a minimum, the spill kit should contain the following:

- Nitrile gloves
- Safety glasses
- Shoe covers
- Tweezers
- Flashlight
- Several pieces of stiff, non-corrugated cardboard
- Paper towels
- Eyedropper
- Duct tape
- Sheets of plastic or garbage bags
- Sealable plastic bags
- 5 gallon bucket with a lid
- Spray bottle
- Hg Absorb™ powder (or other commercially available product)

Preparing to Clean a Mercury Spill

Before cleaning a mercury spill:

- Do not use a standard vacuum cleaner to clean up mercury. The vacuum filter is not capable of containing mercury and will spray small droplets and vapor into the air. Once a vacuum has been used to clean up mercury it is permanently contaminated and must be discarded.

- Do not use a broom to clean up mercury. The broom will break the mercury into smaller droplets and spread the contamination.

- Do not pour liquid mercury down the drain. Mercury will contaminate the drain and the local water treatment plant. Mercury is highly hazardous to the environment.

- Do not attempt to clean mercury from fabric, upholstery, or carpet. It is impossible to remove all mercury contamination from these materials therefore they must be discarded.

- Do not wash mercury-contaminated clothing in a washing machine or dryer. All contaminated clothing must be disposed of as hazardous waste.

Cleaning a Small Mercury Spill

Follow these procedures when cleaning up a small amount of mercury (e.g. thermometer spill).

1. **Evacuate the spill area.** Make sure anyone with contaminated clothing or shoes leaves these articles behind before they leave. These items should be placed in a sealable plastic bag for disposal.
2. **Lower the temperature** in the area, whenever possible. Mercury is a liquid at room temperature but at higher temperature can easily become a vapor which may then be inhaled.
3. **Isolate the ventilation** in the affected area. Contact the Facilities Support Center to shut down HVAC equipment, whenever possible. Ventilation grates in the spill area should be covered with plastic to prevent mercury vapors from traveling to other parts of the building.
4. **Open the windows,** if they are operable. Allow any mercury vapors to escape outside
5. **Protect yourself.** Make sure you are dressed in clothing which completely covers your arms and legs. Put on gloves, shoe covers, and safety glasses. Remove all metal jewelry before attempting to clean up mercury. Mercury will bond to metal jewelry.
6. **Contain the spill.** Protect environmental receptors such as sinks or floor drains.

    A. **Spills on hard, smooth surfaces**

        i. Use two pieces of stiff cardboard to push debris and beads of mercury together and then scoop them up. Place the collected material and the pieces of cardboard in the plastic container.
        ii. Pick up pieces of broken glass with tweezers and place in the plastic container.
        iii. Use the eyedropper to suck up small beads of mercury that cannot be gathered using the cardboard. If you need to expel the eyedropper, gently do so onto a wet paper towel placed inside the plastic container. Discard the eyedropper in the plastic container when finished. Alternatively, you can use the duct tape to pick up very small droplets of mercury only. Discard the tape in the plastic container.
        iv. Turn on the flashlight and shine it over the spill area. Light will reflect off of broken glass and bead of mercury. This will help in locating any remaining spilled materials.

    B. **Spills on carpets, rugs, or fabric**

        i. If the spill is on an area rug, roll the area rug up. Wrap the rug in two layers of plastic sheeting and proceed to the disposal section of this document.
        ii. If the spill is on wall-to-wall carpeting, do not attempt to cut out the affected area yourself. Cutting and tugging actions can disperse

additional mercury into the indoor environment. Isolate the affected room and contact the Environmental Health and Safety Office for assistance.

iii. If the spill is on upholstery contact the Office of Environmental Health and Safety for disposal.

C. **Mercury Spilled in Water**

i. If the liquid mercury fell into a sink full of water, recover the mercury beads using an eyedropper.
ii. Expel the eyedropper into a sealable container.
iii. Once complete the remaining water can be flushed to the sewer as mercury is not soluble in water.
iv. Proceed to the disposal section of this document.

D. **Mercury Spilled Down the Drain**

If the liquid mercury went down a sink drain, contact the Environmental Health and Safety Office immediately for assistance.

7. **Sprinkle the Hg Absorb™ powder over the spill site.** This material will bind any remaining mercury from the spill. Hg Absorb™ powder may be sprinkled on wall-to-wall carpeting or upholstery in anticipation of disposal to prevent further mercury vapor generation. After sprinkling the powder, mist lightly with water and secure the area.
8. **Lightly mist the area** with water to prevent dust generation during cleanup.
9. **Collect the powder** with a moist paper towel and dispose in the plastic bucket.
10. **Dispose of all materials** used in the spill cleanup as mercury waste. If any clothing came into contact with mercury, dispose of this clothing as mercury-contaminated waste.
11. **Seal all bags and containers of waste.** The plastic bucket should be taped around the seal. Label the material as hazardous waste and call the Office of Environmental Health and Safety to schedule a pickup.
12. **Wash your hands** when finished.
13. **Contact the Office of Environmental Health and Safety** with any questions or concerns about the spill.

Section 5: Environmental Chemical Releases

If a spill reaches the environment (floor drain, sink drain, etc.), immediately contact OEHS at 862-4041. Attempt to stop or contain the spill/release at the source without endangering yourself and others by following these procedures:

1. Extinguish all sources of ignition.
2. Isolate all potential environmental receptors (e.g. drains, sumps, soil, etc.).
3. Immediately report the spill/release to OEHS.
4. Wait for OEHS to arrive on the scene.

Section 6: Biological Spills

See **Chapter 10 – Biological Safety** in this manual for information on biological spills.

Section 7: Fire or Explosion

In the event of a fire or explosion*:

1. Evacuate the fire area.
2. Notify occupants nearby.
3. Close the door to the fire area.
4. Activate the building fire alarm system.
5. Dial 911 and report exact location of fire.
6. Evacuate and stay clear of building.

* Departmental protocols may require faculty, staff and students to be trained to use a fire extinguisher. There is no requirement to use a fire extinguisher in the event of a fire. Consult with your administrator or OEHS for additional information regarding departmental procedures.

Section 8: Accidents and Injuries

Serious injuries that require an ambulance must be reported to the University Police Department at 911.

All other injuries should be assessed by a medical care provider (Health Services Center, 862-1098 or your own physician) and should be reported as soon as possible to the faculty member, Department Chair and OEHS. For a chemical exposure, medical personnel should be given the following information:

- Identity of chemical(s).
- Conditions under which exposures occurred.
- Signs and symptoms of exposure.

Whenever possible, a MSDS should be provided. In addition, a written report should be forwarded by the head of the laboratory, to the Department Chair and to OEHS. A "Report of Injury/Occupational Injury" form is available on the OEHS website at http://www.unh.edu/ehs/workers-comp.htm.

Chapter 6 – Exposure Monitoring & Medical Treatment

Section 1: Exposure Monitoring

Section 2: Medical Examination and Consultation

Section 1: Exposure Monitoring

Regular environmental or employee exposure monitoring of airborne concentrations is not warranted or practical in laboratories because the chemicals are used for relatively short periods of time and in small quantities. All procedures are designed to minimize possible exposures. Sampling may be appropriate when highly toxic substances are used regularly. Laboratory employees who suspect that they have been overexposed to a toxic chemical should report to UNH Health Services Center (862-1098) during normal operating hours or call 911 for after-hour emergencies. Notify OEHS of the exposure. An initial exposure assessment will be made by a safety specialist from OEHS and if warranted, specific monitoring will be conducted.

Section 2: Medical Examination and Consultation

A physician is available at UNH Health Services Center (862-1098) to respond to general health concerns for all UNH faculty, staff, students and visitors. A medical provider should be consulted when:

- An employee or student develops signs and symptoms of exposure.
- An event takes place resulting in the likelihood of an exposure.
- Exposure monitoring is above the OSHA "action level."
- There are special concerns about chemicals such as reproductive toxins.

In addition, special health and educational programs have been set up for:

1. Laboratory animal care personnel and feral animal handlers.
2. Personnel handling human blood, body fluids or tissues.

Moreover, recommendations for immunization and/or medical surveillance may be made for personnel working with pathogenic agents or extremely toxic chemicals. For recommendations or referrals to an occupational health provider call OEHS.

Chapter 7 – Training & Information

Section 1: Training and Information Policy

Faculty members are responsible for insuring that their employees and students receive proper training as stipulated in this **Laboratory Safety Plan.**

An on-line, web-based course is currently available for Hazardous Waste Training through the UNH Blackboard system. Please contact OEHS to request enrollment. OEHS also provides the following trainings sessions:

- Biological Safety and Sharps Training
- Biomechanics of Lifting Training
- Bloodborne Pathogens Training
- UNHCEMS™ User Training
- Chemical Safety Training
- Confined Space Entry Training
- Ergonomics in the Office Environment Training
- Fall Protection Training
- Hazardous Waste Management Training
- Laser Safety Training
- Lead Paint Awareness Training
- Noise and Hearing Conservation Training
- Radiation Safety Training
- Respiratory Protection

Training may be required for faculty, staff, students and other personnel. See training descriptions on the following pages for more information. One-on-one training sessions are available. Please contact OEHS at 862-4041 to request any of the above-listed trainings or for additional information.

Section 2: Biological Safety and Sharps Training

This training is required for all incoming undergraduate and graduate students who will be working with infectious materials. Any students working with infectious materials that have not previously had this training must also attend. Faculty and staff are encouraged to attend. ***Biological Safety and Sharps Training*** will include:

- UNH **Laboratory Safety Plan.**
- Biosafety levels and what they mean.
- Basic toxicology including routes of entry.
- Use and disposal of sharps and infectious waste.
- Accidental exposures.
- General information on safety equipment and personal protective equipment.
- Cleaning up spills.
- *Video:* HHMI "Practicing Safe Science."

This training lasts approximately 1 hour.

Section 3: Biomechanics of Lifting Training

The ***Biomechanics of Lifting Training*** addresses the basics of safe lifting and exercises that one can do to reduce the likelihood of a back injury. The class is approximately 30 minutes in length.

Section 4: Bloodborne Pathogens Training

Bloodborne Pathogens Training is required for all individuals who may come in contact with human blood or potentially infectious material as a part of their jobs. The refresher training is required annually and is approximately one hour in length.

Section 5: UNHCEMS™ User Training

UNHCEMS™ User Training covers the use of CEMS for the procurement of biological and chemical agents, including new account numbers for Fisher, Sigma-Aldrich and VWR, chemical inventories, purchasing and pollution prevention. A question and answer period will follow the presentation.

Section 6: Chemical Safety Training

This training is required for all incoming undergraduate and graduate students who will be working with hazardous chemicals. Any students working with hazardous chemicals that have not previously had this training must also attend. Faculty and staff are encouraged to attend. ***Chemical Safety Training*** will include:

- General information on physical and health hazards of hazardous chemicals, signs and symptoms of exposure and measures employees can take to protect themselves.
- Proper use of chemical fume hoods.
- Methods that may be used to detect the presence of a hazardous chemical.
- General information on safety equipment and personal protective equipment.
- *Video:* HHMI "Chemical Hazards" and "Chemical Storage Hazards."

Section 7: Confined Space Entry Training

Confined Space Entry Training is required for anyone entering a confined space at UNH. The class material will describe safe work procedures for working in confined spaces. A confined space is defined as:

- A space that is large enough and so configured that a person can bodily enter to perform assigned work,
- Has limited means for entry or exit, and
- Is not designed for continuous occupancy.

This is a full day class (6-8 hours).

Section 8: Ergonomics in the Office Environmental Training

The ***Ergonomics in the Office Environmental Training*** session addresses the principles of ergonomics as it relates to the computer workstation (seated or standing). Attendees leave with the ability to evaluate their personal workstation. Additional sessions may be requested at department locations.

Section 9: Fall Protection Training

The ***Fall Protection Training*** reviews the proper use of scaffolding and ladders as well as UNH policy on the use of fall protection. Departments need to arrange this training so that specific issues may be addressed related to individual jobs.

Section 10: Hazardous Waste Management Training

The ***Hazardous Waste Management Training*** is mandatory for all those handling, generating or managing regulated waste. This training is available on-line and takes approximately 30-45 minutes to complete. In addition, faculty members need to provide training to supplement OEHS training. This includes specific information on:

- Location of the **Hazardous Waste Management Plan**.
- Hazards and signs and symptoms of exposure associated with chemicals.
- Personal protective equipment required.
- Laboratory procedures for emergencies and for handling hazardous materials.

Section 11: Laser Safety Training

This training is required for anyone operating Class 3B or Class 4 lasers. This training covers the basic modes of exposure and use of personal protective equipment.

Section 12: Lead Paint Awareness Training

The ***Lead Paint Awareness Training*** is provided to individuals who remove or work with lead paint at UNH. The training includes:

- Legal and liability issues.
- History and sources of lead based paint.
- Heath effects of lead exposure.
- State and federal regulations.
- Testing for lead based paint.
- Work site preparation and clean up.
- Work practices.

Section 13: Noise and Hearing Conservation Training

The ***Noise and Hearing Conservation Training*** awareness training is geared toward employees who may be exposed to noises that exceed 90 decibels (dB-A). This class covers the use of hearing protection as well as tactics that should be used to reduce the noise level.

Section 14: Radiation Safety Training

Radiation Awareness

This one and a half hour general awareness class is mandatory for any individual who will work in an area where radioactive materials are used, stored, or handled. This class does not authorize an individual to handle or use sources of radiation. It will be offered upon request, typically monthly.

Radioactive Material User Training

This seven-hour class is required for any individual who will directly handle radioactive material. Upon successful completion of the class and written exam an individual will be listed on a Radioactive Material User Permit and may begin using sources of radiation after completing lab-specific training. It will be offered upon request, typically monthly.

Section 15: Respiratory Protection Training

The ***Respiratory Protection Training*** is required for all individuals who will be required to wear respiratory protection for part of their job. This 45-60 minute class concludes with the distribution of the medical surveillance form. Once the medical surveillance portion of the **Respiratory Protection Program** has been completed, individuals may be called back for respirator fit tests, if applicable.

Section 16: Hazardous Materials Shipping Training

This training is required for any person shipping a hazardous material by ground, air, or vessel. Shipments of hazardous materials can be made by following directions in a UNH shipping guidance document, or by contacting OEHS at 862-4041. Materials that may be considered hazardous for shipment include paint, batteries, field collection solutions, aerosol cans, compressed gas, fuel bottles, infectious materials, strong magnets, fiberglass repair kits, fire extinguishers, and signal flares. In addition, the following guidance documents are available on the **OEHS website**:

- UNH Shipment of Biological Materials Manual;
- UNH Guide to Shipping with Dry Ice;
- UNH Shipment of Hazardous Materials Manual;
- Guidelines for the Shipment of Excepted Quantities of Flammable Liquids;
- Small Quantity Exceptions; and
- UNH Guidelines for Shipment of Formaldehyde Solutions by Air.

Chapter 8 – Recordkeeping

Section 1: Medical Records

Section 2: Training Records

Section 1: Medical Records

Confidential medical records are maintained for employees and students receiving medical surveillance and medical care at UNH Health Services or other designated health care facility (contact OEHS at 862-4041 for more information).

Section 2: Training Records

At a minimum, training records must include the following information:

1. Date of training session.
2. Contents or summary of the training.
3. Name of person attending the training.
4. Names of persons conducting the training.

Records for training are maintained in the OEHS office. Copies are forwarded to the Department Chair, upon request. Records for additional safety training required by departments or individual faculty members are kept in department offices or by the responsible faculty member.

Chapter 9 – Handling and Disposal of Chemicals

Section 1: Chemical Procurement and Distribution

Section 2: Chemical Storage

Section 3: Labeling Chemicals

Section 4: Material Safety Data Sheets

Section 5: Chemical Inventory

Section 6: Transportation of Chemicals

Section 7: Chemical Waste

Section 8: Special Handling Procedures for Chemicals

- Flammable Liquids
- Storage of Flammable Liquids
- Safety Cans
- Flammable Storage Cabinets
- Flammable Storage Refrigerators
- Corrosive Chemicals
- Compressed Gases
- Procedures for Proper Handling of Gas Cylinders

Section 9: Particularly Hazardous Chemicals

- Highly Reactive Chemicals
- Peroxidizable Compounds
- Chemicals of High Acute and Chronic Toxicity

Section 10: Accepting Hazardous Chemicals

Section 1: Chemical Procurement and Distribution

1. Plan experiments with safety in mind. Substitute less hazardous chemicals in laboratory procedures whenever possible. Examples include substituting methyl tertiary-butyl ether (MTBE) for ethyl ether, toluene for benzene and dichloromethane for chloroform and carbon tetrachloride. Minimize the use of mercury in the laboratory and replace mercury-containing devices with non-mercury options whenever possible.

2. Before ordering new chemicals, check the chemical surplus list on the UNHCEMS™ website at http://www.cems.sr.unh.edu to see if the chemical you need is available for free. 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.

3. Orders for all hazardous chemicals and regulated biological agents should be shipped to the Chemical Transfer Station* using the instructions listed below (also be found at http://www.unh.edu/cems/Chemical_Order.htm). **Note:** Packages weighing more than 75 pounds (34 kg) require special arrangements and must not be sent to the Chemical Transfer Station. Please call the Office of Environmental Health and Safety at 862-4041 for more information.

   * The Chemistry Department has all orders shipped to the chemistry stockroom.

Chemical and Biological Agent Ordering Instructions
Fisher: http://www.fishersci.com (800) 766-7000
For chemical orders only register to use account number 766389-001 by following these detailed instructions. This account number ships orders to the Chemical Transfer Station, 1 Leavitt Lane. When making chemical orders, enter in the attention line the building and room number to which you want the chemicals delivered.
Sigma-Aldrich: http://www.sigmaaldrich.com/pipeline (800) 325-3010
Register for an online chemical ordering account with the web-link provided via email by Sigma-Aldrich. Orders with this account will be shipped to the Chemical Transfer Station, 1 Leavitt Lane. For each chemical order, enter in the attention line the building and room number where you want the chemicals delivered. UNH's corporate account number for chemicals is USA_UNH.
VWR: http://www.vwrsp.com (800) 932-5000
When ordering chemicals, use an account number that ships to the UNH Chemical Transfer Station, 1 Leavitt Lane. These account numbers can be found at http://www.unh.edu/cems/vwraccountnumbers.pdf. For each chemical order, enter in the attention line the building and room number where you want the chemicals delivered.

For chemical orders made with all other suppliers:	
Shipping Instructions:	**For Chemistry Department only:**
1. Use this "ship-to" address: [Your Name] UNH Chemical Transfer Station 1 Leavitt Lane, Room 132 Durham, NH 03824 2. Enter in the attention line the building and room where you want the chemicals delivered. **Note:** Online ordering is the preferred method because both you and EH&S receive a confirmation email. This will assist EH&S in scheduling deliveries.	1. Use this "ship-to" address: [Your Name] Parsons Hall, Room 143 23 College Road Durham, NH 03824 2. Enter in the attention line the building and room where you want the chemicals delivered.
Reminder: Before you order, check the UNH Chemical Surplus List at the online inventory http://www.cems.sr.unh.edu where the chemical may be available at NO COST.	
If you need a UNHCEMS™ account or have any questions on how to make chemical orders, call the Office of Environmental Health and Safety at 862-4041.	

4. MSDS can be found at http://www.cems.sr.unh.edu or through a chemical vendor.

5. Keep your chemical inventory and your emergency signs updated at http://www.cems.sr.unh.edu.

6. 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 OEHS for assistance.

Section 2: Chemical Storage

The number and amounts of chemicals that need to be stored should be reduced to an absolute minimum. 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. Information on incompatible chemicals is available in **Appendix O** or from references listed in **Appendix B**. Additional information is available online at http://www.unh.edu/ehs/pdf/Suggested-Storage-Patterns.pdf.

The following are general guidelines:

- Storage areas should be well ventilated (consult with OEHS).
- Large containers of reagents should be stored on low shelving, preferably in trays to contain all leaks and spills.
- Chemicals should not be stored on the floor, on bench tops, or inside fume hoods.
- Inventories of storage areas should be conducted on an ongoing basis and results should be posted on the UNHCEMS™ website at http://www.cems.sr.unh.edu.
- Odiferous chemicals should be stored inside vented cabinets or fume hoods.
- Reactive chemicals should be stored appropriately.
- Flammables requiring refrigeration shall be stored in explosion-safe refrigerators.

Section 3: Labeling Chemicals

All containers must be dated and labeled with the chemical constituents and hazard. It is recommended that the user's name also appear on the label. Labels on incoming containers must not be removed or defaced. Dating 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).

Identifying unknown materials for disposal is extremely costly. All laboratory personnel who are leaving the University are responsible for identifying and properly disposing of the chemical waste in their laboratory. Contact OEHS for additional information.

Section 4: Material Safety Data Sheets

The Material Safety Data Sheet, or MSDS, is a summary of safety information for a hazardous substance or material. The Occupational Safety and Health Administration (OSHA) requires manufacturers and importers of chemicals to develop a MSDS for these materials. The MSDS must include the chemical and common names of all ingredients that have been determined to be health hazards if they constitute 1% or greater of the product's composition (0.1% for carcinogens). The MSDS typically includes information about a chemical's toxicity, health hazards, physical properties, fire and reactivity data, as well as storage, spill and handling precautions. UNH provides Material Safety Data Sheets through UNHCEMS™ at http://www.cems.sr.unh.edu/.

Section 5: Chemical Inventory

The OSHA Hazard Communication Standard and the Durham Fire Department requires UNH to maintain an inventory of hazardous chemicals. 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 at UNH must be registered through UNHCEMS™.

OEHS recommends that any chemical with a MSDS be included in the UNHCEMS™ inventory. The National Fire Protection Association (NFPA) also recommends that an inventory of all hazardous and non-hazardous materials be maintained. The Durham

Fire Department uses the online UNHCEMS™ inventory when responding to an emergency.

Section 6: 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 containers in a passenger elevator without the use of secondary containers.

Section 7: 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 **UNH Hazardous Waste Management Plan**. This document is available on the OEHS website at http://www.unh.edu/ehs/pdf/HWMP.pdf.

UNH has the following requirements for chemical waste containers:

- ***Labeling:*** The label must contain the information shown on the OEHS provided hazardous waste labels and be completely filled out.
- ***Packaging:*** The chemical waste container must have a cap in place at all times, except when actively filling or discharging the bottle or can. Place the primary, chemical container into a secondary container for additional protection.
- ***Storage:*** The chemical waste must be stored in a location specifically for "Hazardous Waste."
- Hazardous waste that is not properly packaged and labeled cannot be removed by OEHS.

Section 8: Special Handling for Chemicals

Flammable Liquids

Fire hazards are associated with vapors from the flammable liquid. In order for a fire to occur, the following conditions must be met:

- Concentration of the vapor must be between the upper and lower explosion limit (See **Appendix A**).
- An oxidizing material must be present.
- Source of ignition.

To work safely with flammable liquids:

- Order only the amounts that are necessary.

- 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, ground both containers. Avoid the use of plastic containers which require special grounding techniques.
- Store flammable liquids in safety cans, flammable storage cabinets or flammable storage refrigerators.
- Locate all distillation apparatus inside the fume hood.
- Do not leave solvent distillation processes unattended.

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.
- Storage of flammable liquids outside approved flammable storage cabinets and safety cans must not exceed 10 gallons per 100 square feet of laboratory space, including waste. See the following tables.
- If you have flammable storage cabinets and approved safety cans, storage must not exceed 20 gallons per 100 square feet of laboratory space. See the following tables.

There are also maximum container size requirements for different classes of flammable liquids and limits for the maximum amounts stored in a laboratory (see below). Consult OEHS for more information.

Table 1. Flash/Boiling Points for NFPA Categories.

	Flash Point		Boiling Point	
TYPE	Fahrenheit	Celsius	Fahrenheit	Celsius
Class IA	< 73	< 22.8	< 100	< 37.8
Class IB	< 73	< 22.8	> 100	> 37.8
Class IC	73 - 100	22.8 - 37.8		
Class II	100 - 140	37.8 - 60		
Class IIIA	140 - 200	60 - 93.3		
Class IIIB	> 200	> 93.3		

Table 2. Maximum Allowable Container Capacity.

	Flammable Liquids			Combustible Liquids	
Container Type	**IA**	**IB**	**IC**	**II**	**IIIA**
Glass	500 mL (1 pt)	1 L (1 qt)	4 L (1.1 gal)	4 L (1.1 gal)	20 L (5 gal)
Metal (other than DOT drums) or approved plastic	4 L (1.1 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)
Safety cans	10 L (2.6 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)	20 L (5 gal)
Metal container (DOT specification)	4 L (1.1 gal)	20 L (5 gal)	20 L (5 gal)	227 L (60 gal)	227 L (60 gal)
Polyethylene (DOT Specification 34, UN 1H1, or as authorized by DOT exemption)	4 L (1.1 gal)	20 L (5 gal)	20 L (5 gal)	227 L (60 gal)	227 L (60 gal)

Table 3. Maximum Quantities of Flammable and Combustible Liquids and Liquefied Flammable Gases in Sprinklered Laboratory Units Outside of Inside Liquid Storage Areas*

Laboratory Unit Fire Hazard Class	Flammable and Combustible Liquid Class	Maximum Quantity per 9.3 m² (100 ft²) of Laboratory Unit		Maximum Quantity per Laboratory Unit		Maximum Quantity per 9.3 m² (100 ft²) of Laboratory Unit		Maximum Quantity per Laboratory Unit	
		Excluding Quantities in Storage Cabinets or Safety Cans				*Including* Quantities in Storage Cabinets or Safety Cans			
		L	Gal	L	gal	L	gal	L	gal
A (High)	I	38	10	2270	600	76	20	4540	1200
	I, II and IIIA	76	20	3028	800	150	40	6060	1600
B (Moderate)	I	20	5	1136	300	38	10	2270	600
	I, II and IIIA	38	10	1515	400	76	20	3028	800
C (Low)	I	7.5	2	570	150	15	4	1136	300
	I, II and IIIA	15	4	757	200	30	8	1515	400
D (Minimum)	I	4	1.1	284	75	7.5	2	570	150
	I, II and IIIA	4	1.1	284	75	7.5	2	570	150

Table 4. Maximum Quantities of Flammable and Combustible Liquids and Liquefied Flammable Gases in Nonsprinklered Laboratory Units Outside of Inside Liquid Storage Areas*

Laboratory Unit Fire Hazard Class	Flammable and Combustible Liquid Class	Maximum Quantity per 9.3 m² (100 ft²) of Laboratory Unit		Maximum Quantity per Laboratory Unit		Maximum Quantity per 9.3 m² (100 ft²) of Laboratory Unit		Maximum Quantity per Laboratory Unit	
		Excluding Quantities in Storage Cabinets or Safety Cans				*Including* Quantities in Storage Cabinets or Safety Cans			
		L	gal	L	gal	L	gal	L	Gal
A (High)	I	Not permitted		Not permitted		Not permitted		Not permitted	
	I, II and IIIA	Not permitted		Not permitted		Not permitted		Not permitted	
B (Moderate)	I	Not permitted		Not permitted		Not permitted		Not permitted	
	I, II and IIIA	Not permitted		Not permitted		Not permitted		Not permitted	
C (Low)	I	7.5	2	284	75	15	4	570	150
	I, II and IIIA	15	4	380	100	30	8	760	200
D (Minimum)	I	4	1.1	140	37	7.5	2	284	75
	I, II and IIIA	4	1.1	140	37	7.5	2	284	75

*** NFPA 45, Fire Protection for Laboratories Using Chemicals, National Fire Protection Association**

Table 5. Maximum Quantity Permitted Excluding Storage Cabinet and Safety Cans*

Laboratory unit fire hazard class	Flammable or combustible liquid class	Excluding Quantities in Storage Cabinets or Safety Cans		
		Maximum quantity per 100 sq ft of laboratory unit	Maximum quantity per laboratory unit	
			Without sprinklers	*With sprinklers*
A (High)	1 I, II and IIIA	10 gallons 20 gallons	300 gallons 400 gallons	600 gallons 800 gallons
B (Moderate)	1 I, II and IIIA	5 gallons 10 gallons	150 gallons 200 gallons	300 gallons 400 gallons
C (Low)	1 I, II and IIIA	2 gallons 4 gallons	75 gallons 100 gallons	150 gallons 200 gallons
D (Minimum)	1 I, II and IIIA	1.1 gallons 1.1 gallons	37 gallons 37 gallons	75 gallons 75 gallons

Table 6. Maximum Quantity Permitted Including Storage Cabinet and Safety Cans*

Laboratory unit fire hazard class	Flammable or combustible liquid class	Including quantities in storage cabinets or safety cans		
		Maximum quantity per 100 sq ft of laboratory unit	Maximum quantity per laboratory unit	
			Without sprinklers	*With sprinklers*
A (High)	1 I, II and IIIA	30 gallons 40 gallons	600 gallons 800 gallons	1200 gallons 1600 gallons
B (Moderate)	1 I, II and IIIA	10 gallons 20 gallons	300 gallons 400 gallons	600 gallons 800 gallons
C (Low)	1 I, II and IIIA	4 gallons 5 gallons	150 gallons 200 gallons	300 gallons 400 gallons
D (Minimum)	1 I, II and IIIA	2 gallons 2 gallons	75 gallons 75 gallons	150 gallons 150 gallons

*** NFPA 45, Fire Protection for Laboratories Using Chemicals, National Fire Protection Association**

Safety Cans

Safety cans must be 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.

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 (NFPA), 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 labeled with a sign which reads: "Flammable - Keep Fire Away."
- Materials stored inside of the flammable storage cabinet should be compatible with the cabinet's design and construction.
- Acids should not be stored in a flammable storage cabinet due to possible corrosion of the cabinet and incompatibility with organic solvents.

Flammable Storage Refrigerators

According to Annex A of NFPA 45 – Standard on Fire Protection for Laboratories Using Chemicals:

> "The use of domestic refrigerators for the storage of typical laboratory solvents presents a significant hazard to the laboratory work area. Refrigerator temperatures are almost universally higher than the flash points of the flammable liquids most often stored in them. In addition to vapor accumulation, a domestic refrigerator contains readily available ignition sources, such as thermostats, light switches, and heater strips, all within or exposed to the refrigerated storage compartment. Furthermore, the compressor and its circuits are typically located at the bottom of the unit, where vapors from flammable liquid spills or leaks could easily accumulate."

Flammable storage refrigerators are specially designed to prevent internal explosions caused by flammable vapors coming in contact with ignition sources (e.g. the temperature control switch or the light). In addition, explosion-proof refrigerators and freezers should have an explosion-proof interior and exterior. These refrigerators and freezers must meet UL, NFPA, and OSHA standards.

Due to these concerns, flammable liquids (Class I, IA, IB, and IC) are prohibited in ordinary household-type refrigerators at UNH. The National Fire Protection Association (NFPA) defines flammable liquids as follows:

- ***Class I Liquid -*** Any liquid with a flash point <100°F (37.8°C) and a Reid vapor pressure not exceeding 40 psi (2,068.6 mm Hg) at 100°F (37.8°C).
- ***Class IA Liquids -*** Any liquid with a flash point <73°F (22.8°C) and boiling points below 100°F (37.8°C).
- ***Class IB Liquids -*** Any liquid with a flash point <73°F (22.8°C) and boiling points at or above 100°F (37.8°C).
- ***Class IC Liquids -*** Any liquid with a flash point at or above 73°F (22.8°C), but below 100°F (37.8°C).

In addition, explosion-proof refrigerators and freezers must be used for any chemicals in which:

1. Ignitible concentrations of flammable gases or vapors can exist under normal operating conditions, or
2. Ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or
3. Breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors and might also cause simultaneous failure of electrical equipment in such a way as to directly cause the electrical equipment to become a source of ignition.

In laboratories storing or using flammable liquids, refrigerators should be clearly marked to indicate whether or not it is safe for storage of flammable materials. Internal laboratory procedures must ensure that laboratory refrigerators are being properly used.

Important: Food and beverages are prohibited in UNH laboratories. If food or beverages are being used for research purposes, they must be labeled, "For Experimental Use Only" or "Not for Human Consumption." Food and beverages must never be stored in any laboratory refrigerator in which chemicals, biological, and radioactive materials are kept.

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 with a protective plastic coating, if 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.

Compressed and Liquefied 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 (see **Appendix R**) should be approved by OEHS, prior to implementation.

Although each approved gas cylinder is designed, constructed, and tested to safely contain its contents, the following procedures should be taken in handling and storing of compressed gases.

Procedures for Proper Handling of Gas Cylinders

- 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 is also acceptable.
- Cylinders must be stored in a cool, dry and well-ventilated area away from ignition sources, electrical supply sources and heat.
- A safety cap or regulator must always be attached to the cylinder.
- Transport capped cylinders on an approved cylinder cart.
- 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.
- Do not store cylinders on the tops of shelves or cabinets.
- Keep flammable gases away from doorways.
- Work with particularly hazardous gases with special procedures and in approved gas storage cabinets.

Section 9: Particularly Hazardous Chemicals

Particularly Hazardous Chemicals (PHCs) are designated on the UNHCEMS™ website (http://www.cems.sr.unh.edu) as well as within individual instructional and research laboratory chemical inventories. Please consult the UNHCEMS™ website for appropriate handling and training guidelines. For assistance in identifying other hazardous chemicals, see **appendices O – T.**

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 (see **Appendix P**) and peroxide formers (see **Appendix Q** and **Table 7**). 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:

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

If the risks are high, experiments should be performed in an isolated facility with explosion venting and explosion-resistant construction.

Peroxidizable Compounds

Peroxides can form and accumulate under normal storage conditions. Peroxides may also explode violently when chemicals are subject to thermal or mechanical shock. See **Appendix Q** and **Table 7** on the next page for examples of common peroxidizable compounds.

Table 7. Classes of Chemicals that can Form Peroxides Upon Aging*

Class I - Unsaturated materials, especially those of low molecular weight, may polymerize violently and hazardously due to peroxide initiation. (***Discard After One Year)***	**Class II** - The following chemicals are a peroxide hazard upon concentration (distillation or evaporation). A test for peroxide should be performed if concentration is intended or suspected. ***(Discard After One Year)***	**Class III** - Peroxides derived from the following compound may explode without concentration. ***(Discard After Three Months)***
Acrylic acid Acrylonitrile Butadiene Chlorobutadiene (chloroprene) Chlorotrifluoroethylene Methyl methacrylate Styrene Tetrafluoroethylene Vinyl acetate Vinyl acetylene Vinyl chloride Vinyl pyridine Vinylidene chloride	Acetal Cumene Cyclohexene Cyclooctene Cyclopentene Diacetylene Dicyclopentadiene Diethylene glycol dimethyl ether (diglyme) Diethyl ether Dioxane (*p*-dioxane) Ethylene glycol dimethyl ether (glyme) Furan Methyl acetylene Methyl cyclopentane Methyl-*i*-butyl ketone Tetrahydrofuran Tetrahydronaphthalene Vinyl ethers	***Organic*** Divinyl ether Divinyl acetylene Isopropyl ether Vinylidene chloride ***Inorganic*** Potassium metal Potassium amide Sodium amide (solamide)

* Lists are illustrative and not exhaustive.
Reference: Prudent Practices in the Laboratory, "Handling and Disposal of Chemicals," National Academy Press, 1995.

To prevent accidents, peroxidizable compounds should be identified, dated upon opening, inventoried, and evaluated for safe use after three months. Do not store peroxidizable compounds in colorless glass bottles. Formation of peroxides is catalyzed by light. More information is available in the National Safety Council Publication, "Recognition and Handling of Peroxidizable Compounds." Questions regarding the use and storage of peroxidizable materials should be directed to the Office of Environmental Health and Safety.

Use these precautions when handling peroxide-forming agents:

1. Know the properties and hazards of the material you are using through adequate research and study, including reading the label and MSDS.

2. When receiving a bottle of the material, write "Received on:" and the date on the label. Ensure that the chemical has been entered into the UNH Chemical Environmental Management System at http://www.cems.sr.unh.edu.

3. When opening the bottle for the first time, write "Opened on:" and the date on the label.

4. Establish a laboratory routine to test all peroxide-forming chemicals on the first day of each month (or no later than every 3 months).

5. Do not purchase more of the chemical than can be reasonably used in three month's time. Peroxides can build up over time as solvent evaporates and/or air seeps into the bottle.

6. If possible, purchase material that contains an appropriate peroxide inhibitor such as BHT (butylated hydroxyl toluene). If non-inhibited material must be stored, be sure to store the material under an inert atmosphere of nitrogen or argon and test it for peroxides at least once a month.

7. Do not distill, evaporate, or concentrate the material until it has been tested for the presence of peroxides. Peroxides are usually less volatile than their parent material and tend to concentrate upon distillation.

8. 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 which must be opened to see inside.

9. 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.

10. Do not purchase or use high-risk items such as di-isopropyl ether: use less hazardous alternatives.

11. NEVER touch or attempt to open a container of a peroxide-forming liquid if there are crystals around the cap and/or in the bottle. The vibration/friction of screwing the cap could detonate the bottle with disastrous results.

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 LD_{50} of 500-5,000 mg/kg; very toxic LD_{50} of 50-500 mg/kg, extremely toxic LD_{50} of 5-50mg/kg and supertoxic LD_{50} <5mg/kg, see glossary for explanation of LD_{50}). 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 OEHS.

Substances that have high chronic toxicity cause damage after repeated exposure over a period of time. These may include carcinogens (see **Appendix S**), reproductive toxins, mutagens, teratogens and sensitizers. Laboratory personnel (male and female), especially those 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 OEHS and a personal physician or a health physician at UNH Health Services 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 employees 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. Call OEHS for disposal.
- Establish an emergency plan for each operation.
- Decontaminate work surfaces after completing procedures.
- Do not conduct normal laboratory work in the designated area until decontaminated.

Section 10: Accepting Hazardous Materials

The Office of Environmental Health and Safety (OEHS) must approve all hazardous material transfers to UNH property. Faculty, staff, students, visitors and guests are prohibited from accepting hazardous materials, including but not limited to chemicals, without first receiving approval from OEHS. Please contact OEHS at 862-4041 for more information.

Chapter 10 – Biological Safety

Section 1: Pathogenic Microorganisms

Section 2: Laboratory Animals

Section 3: Human Blood and Body Fluids

Section 4: Recombinant DNA

Section 5: Environmental Samples

Section 6: Reproductive Toxins, Teratogenic Agents and Pregnancy

Section 7: Importation and Interstate Shipment of Pathogens

Section 8: Biosafety Practices and Safety Equipment

Biohazard Laboratory Inspections
Biohazard Signs and Labels

Section 9: Biological Spills

Spill in a Biosafety Cabinet
Small Spill of BSL-1 or BSL-2 Material Outside of a Safety Cabinet
Large Spill of BSL-1 Material Outside of a Safety Cabinet (>500 mL)
Blood
Large Spill of BSL-2 Material Outside of a Safety Cabinet (>500 mL)
Any BSL-3 Spill Outside of a Safety Cabinet
Spill of Biological Radioactive Material
Clean-up of a Biological Radioactive Spills

Section 10: Flow Cytometry for Live and Fixed Cells

Section 11: Ethidium Bromide Disposal

Section 12: Universal Precaution

Bloodborne Disease Transmission
Materials to be Handled Using Universal Precautions
Bloodborne Disease Statistics
Personal Protective Equipment

Section 13: Autoclave Maintenance and Testing

Section 14: Biohazard Waste Disposal Practices

Section 1: Pathogenic Microorganisms

The Institutional Biosafety Committee requires that research with pathogenic microorganisms and human blood/body fluids and tissues be registered prior to the initiation of work. For this registration, a pathogen is defined as any organism known to cause infection or suspected of causing infection in humans, animals, insects or plants. Registration forms for Recombinant DNA and Infectious Agents are available on the OEHS website at http://www.unh.edu/ehs/biological-safety.htm.

All faculty, staff and students who are working with microbiological organisms or materials potentially infected with microbial organisms are expected to follow the guidelines specified in Biosafety in Microbiological and Biomedical Laboratories (BMBL) at http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm. The biological agents from the BMBL can be found in **Appendix V**. These guidelines describe four biosafety levels which specify microbiological practices, laboratory facilities and safety equipment. Work with infectious agents is assigned to a specific biosafety level based on the potential hazard of the agent to people. Four biosafety levels are also described for infectious disease activities in which small laboratory animals are used. All questions about biological safety should be directed the Laboratory Safety Officer in OEHS.

Section 2: Laboratory Animals

The occupational health program for personnel who work in laboratory vertebrate animal facilities or who have frequent contact with vertebrate animals is the responsibility of OEHS and includes the following:

1. Medical/work history

    a. Completion of medical and work history documentation and
    b. Pre-work assignment medical work history review.

2. Physical examinations and immunizations (at the discretion of the attending physician)

    a. Pre-work physical examination,
    b. Subsequent periodic physical examinations as required for individuals in some job categories and
    c. Pre-work assignment immunizations and booster injections against tetanus and other diseases to which animal care personnel might be exposed.

3. Reporting of illnesses or injuries

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

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

b. Illnesses suspected of being related to work with animals will be reported to appropriate public health officials by OEHS as required by state or federal regulations.

4. Maintenance of individual health records

a. OEHS maintains records that individuals have participated in the Occupational Health Surveillance Program.
b. All permanent medical records for all registered animal care personnel are maintained at UNH Health Services or the person's medical provider.

5. Surveillance program for zoonotic diseases

a. Two copies of protocols proposing work with zoonotic diseases must be submitted by the project director to OEHS. One copy is forwarded to the UNH Institutional Biosafety Committee for approval consideration; a second copy is retained by OEHS.
b. Personnel are specifically instructed to notify supervisors of illnesses or suspected work-related health problems.
c. Consideration is given to obtaining and storing pre- and post-employment serum samples for future diagnostic purposes from certain registered animal care personnel.

6. Monitoring of hazardous substances

a. Two copies of protocols proposing work with hazardous chemical or physical agents (29 CFR 1910) must be submitted to OEHS. One copy is forwarded to the UNH Chemical Safety Committee for approval consideration; the second copy is retained by OEHS.
b. Personnel are specifically instructed to notify supervisors of illness and suspected work-related health problems.

7. Employee Occupational Health Education Program

a. OEHS and ARO provide pre-work training to personnel about:

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

8. Personal Health Regulations

    a. All employees are expected to maintain acceptable health care and hygiene standards.
    b. Animal care personnel are required to wear lab coats, scrub suits, uniforms or other suitable attire in animal areas. In specific instances other protective clothing may be required.
    c. Under no circumstance is eating, smoking, drinking or application of cosmetics allowed in animal areas.

Section 3: Human Blood and Body Fluids

The Institutional Biosafety Committee requires that research with human blood/body fluids and tissues be registered prior to the initiation of work. Please complete the UNH Registration Document for the Use of Biohazardous Materials (available online at http://www.unh.edu/ehs/pdf/UNH-Infectious-Agent-Registration-Form.pdf).

Laboratory practices should be followed on the assumption that all human blood, body fluid and tissues are infectious (universal precautions). The Centers for Disease Control 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. (Refer to the CDC/NIH BMBL, available online at http://www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.htm for additional information.)

Section 4: Recombinant DNA

The U.S. Department of Health and Human Services has published guidelines which specify practices for constructing and handling recombinant DNA molecules, organisms, and viruses containing recombinant DNA molecules. (Refer to the NIH OBA website, http://www.nih.gov/od/oba/ for additional information.)

Projects proposing recombinant DNA methodologies must be registered with the Institutional Biosafety Committee (IBC). Projects which are subject to the NIH Guidelines are reviewed by the committee. Users must complete the Registration Document for Recombinant DNA Research for IBC review. This document is available online at http://www.unh.edu/ehs/pdf/UNH-rDNA-Registration-Form.pdf. See **Appendix W** for a list of exempt agents and **Appendix X** for the NIH risk groups.

Section 5: Environmental Samples

Environmental samples, such as water, air or earth, may 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. Use care when handling environmental samples, especially if the sample will be enhanced in the

laboratory by culturing or other growing mechanisms. 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 or fume hood. If the environmental sample is sterilized prior to experimentation, then the sample may be manipulated in a BSL-1 rated laboratory.

Research involving environmental samples must be registered with the UNH Institutional Biosafety Committee for approval. The infectious agent registration form can be found at http://www.unh.edu/ehs/biological-safety.htm. If you require assistance determining whether you need to register this research with the IBC, please contact the Laboratory Safety Officer.

Section 6: Reproductive Hazards, Teratogenic Agents, and Pregnancy

Substances or agents that affect the reproductive health of women or men or the ability of couples to have healthy children are called **reproductive hazards**. A **teratogen** is substance which interferes with embryonic or fetal development and women of child bearing potential should take care to avoid exposure. A **fetotoxin** is a substance that can poison or cause degenerative effects in a developing fetus or embryo. Radiation, some chemicals, certain drugs (legal and illegal), cigarettes, some viruses, and alcohol are other examples of reproductive hazards.

A reproductive hazard may cause one or more health effects, depending on the time and duration of the exposure. For example, exposure to harmful substances during the first 3 months of pregnancy may cause a birth defect or a miscarriage. During the last 6 months of pregnancy, exposure to reproductive hazards could slow the growth of the fetus, affect the development of its brain, or cause premature labor.

Reproductive hazards may not affect every person or every pregnancy in the same way. Whether a woman or fetus is harmed depends on how much of the hazard they are exposed to, when they are exposed, how long they are exposed, and how they are exposed.

Faculty members and laboratory supervisors are responsible for training and instructing laboratory personnel in the appropriate ways to protect themselves from the hazards in the laboratory. Students, employees, guests and visitors are responsible for learning about the hazards in their workplace, using personal protective equipment, and following proper work practices. Employees, students, guests and visitors should take the following steps to ensure their own safety:

- Store chemicals in sealed containers when they are not in use.
- Wash hands after contacting hazardous substances and before eating, drinking, or smoking.
- Avoid skin contact with chemicals.
- If chemicals contact the skin, follow the directions for washing and decontamination as described in the material safety data sheet (MSDS). MSDSs can be reviewed online at http://www.cems.sr.unh.edu.
- Review the MSDS for each hazardous chemical used in the laboratory to become familiar with any reproductive hazards.

- Consult a health care provider with any concerns about reproductive hazards in the workplace.
- Participate in all relevant safety and health education, training, and monitoring programs offered by UNH.
- Discuss proper work practices with the faculty member or laboratory supervisor.
- Contact OEHS to discuss potential improvements in engineering controls (e.g. ventilation, chemical fume hoods) or with questions about reproductive hazards.
- Use personal protective equipment (e.g., gloves, respirators, and personal protective clothing) to reduce exposures to workplace hazards.
- Follow appropriate work practices and procedures to prevent exposures to reproductive hazards.

Research or work with chemicals or biological agents possessing teratogenic or mutagenic capabilities, such as ***Rubella***, ***herpes*** or ***cytomegalovirus,*** or other agents that could cause fetal death such as ***Brucella***, may pose a significant health risk. Always consider the health risks associated with any chemical or biological agent before working with the agent and discuss any related concerns with your doctor. Consult faculty members, laboratory supervisors, principal investigators or the Laboratory Safety Officer if you have any questions or concerns about the research being conducted.

POSSIBLE TERATOGENS

Type	Agent	Effect
Medications	ACE Inhibitors	Renal dysgenesis, oligohydramnios sequence, skull ossification defects
	Aminopterin and methotrexate	Pregnancy loss, hydrocephalus, low birth weight, dysmorphic facial features
	Androgens and high doses of nor-progesterones	Masculinization of external female genitalia
	Antithyroid drugs	Hypothyroidism, goiter
	Carbamazepine	Neural tube defects
	Cocaine	Pregnancy loss, placental abruption, growth retardation, microcephaly
	Diethylstilbestrol	Vaginal adenosis/adenocarcinoma, cervical erosion and ridges
	Hydantoin	Dysmorphic facial features, hypoplastic nails, growth and developmental retardation
	Isotretinoin	Pregnancy loss, hydrocephalus, other CNS defects, small or absent thymus, microtia/anotia, conotruncal heart defects
	Lithium	Ebstein anomaly
	Penicillamine	Cutis laxa
	Streptomycin	Hearing loss
	Tetracycline	Stained teeth, enamel hypoplasia
	Thalidomide	Limb reduction defects, ear anomalies
	Trimethadione	Developmental retardation, dysmorphic facial features
	Valproic Acid	Neural tube defects, dysmorphic facial features
	Warfarin	Nasal hypoplasia, stippled epiphyses, CNS defects
Chemical	Lead	Pregnancy loss, CNS damage
	Methylmercury	Cerebral atrophy, spasticity, mental retardation
	Polychloronated biphenyls (PCBs - ingested)	Low birth weight, skin discoloration

Type	Agent	Effect
Maternal Disorder	Autoimmune Disorders	Congenital heart block, pregnancy loss
	Hypertension	Intrauterine growth retardation
	Hypo/Hyperthyroidism	Goiter, growth and developmental retardation
	Insulin Dependent Diabetes Mellitus	Congenital heart defects, caudal deficiency, neural tube defects, limb defects, holoprosencephaly, pregnancy loss
	Phenylketonuria	Pregnancy loss, microcephaly, mental retardation, facial dysmorphism, congenital heart defects
Maternal Infection	Brucella	Brucellosis once in the blood stream and the lymphatics can eventually cause bacteremia (bacterial blood infiltration).
	Coxsackie virus type B	May cause infections like meningitis or sepsis (an overwhelming blood infection)
	Cytomegalovirus	Growth and developmental retardation, microcephaly, hearing loss, occular abnormalities
	Herpes (Active)	Vertical transmission at delivery
	Herpes (Primary)	Pregnancy loss, growth retardation, eye abnormalities
	Human immunodeficiency virus	Possible HIV transmission to fetus
	Human Parvovirus B19	Miscarriage
	Listeria monocytogenes	Intrauterine or cervical infections in pregnant women, which may result in spontaneous abortion (2nd/3rd trimester) or stillbirth
	Syphilis	Abnormal teeth and bones, mental retardation
	Toxoplasma gondii	Hydrocephalus, blindness, mental retardation
	Varicella	Skin scarring, limb reduction defects, muscle atrophy, mental retardation
	Venezuelan Equine Encephalitis	CNS damage, cataracts, pregnancy loss
	Rubella	Disrupt fetal growth and cause birth defects.
Reproductive Toxin	Chronic Alcoholism	Growth and developmental retardation, microcephaly, craniofacial dysmorphism
	Cigarette Smoking	Pregnancy loss, low birth weight
	Hyperthermia	Neural tube defects
	Therapeutic Radiation	Growth and developmental retardation, microcephaly

Section 7: Importation and Interstate Shipment of Pathogens

Etiologic agents of human diseases, vectors, and diagnostic specimens must be packaged, labeled, and shipped in accordance with regulations from the Centers of Disease Control and Prevention, Department of Transportation, U.S. Postal Service and other agencies. In addition, importation of etiologic agents and vectors of human disease are subject to Public Health Service foreign quarantine regulations and permits are required by the Center for Disease Control and Prevention (CDC).

The U.S. Department of Agriculture (http://www.aphis.usda.gov) regulates the importation and interstate shipment of animal and plant pathogens and permits may be required for interstate movement of certain animal or plant pathogens. For more information, please go to http://www.unh.edu/ehs/shipping.htm.

Packaging and Transport of Biological Materials

Secondary containers such as sealable plastic containers are required when biological materials are carried to another laboratory or building. Biological materials that are sent off campus by mail or common carrier must be securely packaged to prevent accidental leakage or breakage. Primary containers must be sealed tightly, surrounded by absorbent packing material to retain leakage and placed in secondary containers. Secondary containers must be sealable and break-resistant. A shipping container with the address label should surround the secondary container. Both primary and secondary containers should be labeled with the type of material being shipped and the names, addresses and telephone numbers of both shippers and receivers. Additional labeling may be required. Please review the UNH Shipment of Biological Materials Manual, available at http://www.unh.edu/ehs/pdf/UNH-Shipping-Biological-Materials.pdf, for more information.

Section 8: Biosafety Practices and Safety Equipment

Biohazard Laboratory Inspections

In addition to routine laboratory inspections, OEHS conducts a biohazard evaluation of all laboratories in which biohazards have been identified, to insure that appropriate facilities and procedures are being used. Microbiological techniques, treatment and disposal of biohazardous waste, safety equipment and facilities and proper training of laboratory personnel are evaluated. See **Appendix D** for a blank biosafety inspection form.

Biohazard Signs and Labels

A biological hazard sign with the international biological warning symbol must be affixed to the doors of all biosafety level 2 or 3 laboratories. In addition, equipment used to store biohazardous materials (e.g. incubators, refrigerators, freezers) and receptacles for storage of biohazardous waste must be labeled. Signs and labels are available from OEHS.

Biological Safety Cabinets and Horizontal Laminar Flow Hoods

See **Chapter 4 – Ventilation** in this manual for information about biological safety cabinets and laminar flow hoods.

Section 9: 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, your 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 biohazard bags.

Biosafety Levels 1, 2 and 3 (BSL-1, BSL-2, BSL-3) require different approaches in how to deal with the spill. Follow the procedures in this section in the event of a biological spill.

Spill in a Biological Safety Cabinet

1. LEAVE THE CABINET TURNED ON.
2. 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.
3. 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.
4. The Laboratory Safety Officer (LSO) should be notified at 862-4041 if the spill overflows into the interior of the cabinet. It may be necessary to do a more extensive cabinet decontamination.

Small spill of BSL-1 or BSL-2 material outside of a safety cabinet (<500 ml spill and able to be covered by a few paper towels)

1. Wearing gloves and a lab coat, cover the spill with paper towels and an appropriate disinfectant.
2. Allow sufficient contact time with disinfectant (usually >20 minutes).
3. Pick up towels and discard into biohazard waste container.
4. Pick up broken glass with forceps and place in Sharps container.
5. 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 (>500 ml)

- **GET HELP! (Call 862-4041)**
- **Notify your supervisor.**
- The methods are the same as for small BSL-1 skills, only on a larger scale.

Blood

1. Wearing household gloves and a lab coat, absorb blood with paper towels.
2. Using a detergent solution, clean the spill site of all visible blood.
3. Wipe down the spill site with paper towels soaked in a disinfectant such as chlorine bleach, diluted 1:10.
4. Discard all contaminated materials in a biohazard waste container.
5. Wash your hands with soap or hand washing disinfectant.

Large spill of BSL-2 material outside of a safety cabinet (>500 ml)

1. **GET HELP! (Call 862-4041)**
2. Keep people out of the area to prevent spread of the contamination. Post sign.
3. Remove any contaminated clothing and put it into a biohazard bag for decontamination later.
4. Wash hands and exposed skin and inform your supervisor about the spill.
5. Put on protective clothing (lab coat, gloves and, if indicated, face protection and shoe covers) and assemble clean-up materials (disinfectant, autoclavable container or bag, forceps and paper towels).
6. Pick up any broken glass with forceps and dispose of it in Sharps container.
7. Ring the spill with disinfectant and mix it into the spill. Take care not to over-dilute the disinfectant.
8. After at least 20 minutes contact time, clean-up liquids and re-wipe the spill area with disinfectant.
9. Collect all contaminated materials for decontamination and wash your hands with soap or hand washing disinfectant.

Any BSL-3 Spill outside of a safety cabinet

GET IMMEDIATE HELP!
Call 862-4041 and notify your supervisor.

A BSL-3 spill outside a biosafety cabinet is a very serious event. As many BSL-3 agents are respiratory pathogens everyone in the room is at risk of becoming infected. It is very important that everyone leaves the room and no cleanup is attempted without specialized equipment.

If there is a BSL-3 spill outside a biosafety cabinet:

1. Immediately alert all persons nearby.
2. Leave the biosafety cabinet on.
3. Avoid breathing vapors of the spilled material.
4. Evacuate the area and close the door to the laboratory facility. Put a "DO NOT ENTER" sign on the door.
5. Call the BSL-3 Facility Director or LSO (862-4041) for assistance. Be prepared to provide the identity, amount and location of the spill, as well as your location, names of those at the scene and a phone number where you can be reached (not your lab phone, since you should not remain in the lab after the spill).

Spill of Biological Radioactive Material

GET IMMEDIATE HELP!
Call 862-4041 and notify your supervisor.

A biohazardous spill involving radioactive material requires emergency procedures that are different from the procedures used for either material alone. Use procedures that protect you from the radionuclide as you disinfect the biohazardous material.

Before any clean-up, consider the type of radionuclide, the characteristics of the micro-organism and the volume of the spill. Contact the RSO at 862-3607 for the isotope clean-up procedures.

First Steps

1. Avoid inhaling airborne material and quickly leave the room.
2. Notify others to leave.
3. Close door and post with warning sign.
4. Remove contaminated clothing, turn exposed area inward and place in a biohazard bag.
5. Wash all exposed skin with disinfectant, followed by a three-minute water rinse.
6. Inform your supervisor and the RSO (862-3607) of the spill and monitor all exposed personnel for radiation. If assistance is needed in handling the micro-organism, contact the LSO (862-4041).
7. Allow aerosols to disperse for at least 30 minutes before reentering the laboratory. Assemble clean-up materials (disinfectant, autoclavable containers, forceps, towels and sponges).
8. Confirm with the RSO if it is safe to enter the lab.

Clean-up of Biological Radioactive Spill

If a high dose is expected, the dose rate must be determined by the Radiation Safety Officer prior to clean-up. If not, disinfect the biohazard first and then complete a dose assessment of the spilled material. Contact the RSO at 862-3607 for assistance.

1. Put on protective clothing (gown, surgical mask, gloves and shoe covers). Depending on the nature of the spill, it may be advisable to wear a HEPA filtered respirator instead of a surgical mask.
2. Cover the area with disinfectant-soaked towels and carefully pour disinfectant around the spill. Avoid enlarging the contaminated area. Use additional concentrated disinfectant as it becomes diluted by the spill. Allow at least 20 minutes contact time. Do not use chlorine bleach solutions on iodinated materials: radioiodine gas may be released. Instead, use an alternative disinfectant such as an iodophoric or a phenolic compound.
3. Handle any sharp objects with forceps.
4. Do not autoclave contaminated waste unless approved by the RSO (862-3607).
5. Wipe surrounding areas, where the spill may have splashed, with disinfectant.
6. Soak up the disinfectant and spill and place the decontamination materials, along with protective clothing, into an approved radiation waste container and label it according to Radiation Safety Guidelines.
7. Wash hands and exposed skin areas with disinfectant and monitor personnel and spill area for residual radioactive contamination. If skin contamination is detected, repeat decontamination procedures under the direction of the RSO. If spill area has residual activity, determine if it is fixed or removable and handle it accordingly.
8. Contaminated protective clothing must be disinfected prior to disposal as radioactive waste. Contact the RSO at 862-3607 for instructions.
9. If any items are found to be radioactive, spray with disinfectant and allow at least a 20 minute contact time.
10. Wrap the item(s) inside the adsorbent paper and dispose of as radioactive waste.

The waste involved in this type of clean-up is called "mixed-waste" because it contains biological infectious agents and radioactive material. Therefore, it must be labeled with a "radioactive material" tag and the "biohazard symbol."

Section 10: Flow Cytometry for Live and Fixed Cells

Flow cytometry is a method of quantifying structural or biochemical features of cells or other small particles by using a laser as an excitation light source and photodetectors for measurement. This is generally accomplished by either light scatter and/or fluorescence. Flow cytometry may further be defined as a technology to measure properties of particles as they move or flow, in liquid suspension.

In some flow (or sorting) cytometers, the liquid containing the particles is broken into droplets by the reciprocating motion of a nozzle. Individual particles are captured in small droplets and then those droplets are electrostatically charged and deflected through a high potential. If a plug or other obstruction (bubbles, clumps of cells, etc.) occurs, then this stream of droplets can go awry, generating aerosols. There is a

potential for aerosol exposure to individuals near a flow cytometer because modern sorting units operate with 14 to 40 pounds per square inch of pressure (some units can operate at 100 psi). Even non-sorting flow cytometers, which do not suspend cells in droplets, operate under pressures near 5 psi and can develop leaks and generate aerosols.

The following requirements must be followed when using a flow cytometer at UNH due to the potential for aerosol exposure to individuals:

1. Flow cytometry must be conducted in a negative pressure laboratory.
2. Flow cytometry may only be performed by individuals trained in the proper use of the unit.
3. Proper personal protective equipment should be worn when using a flow cytometer. This may include gloves, lab coats and safety glasses.
4. The flow cytometer and lab bench must be cleaned and properly disinfected after each use.
5. The catch basin should have an adequate disinfectant (i.e. bleach) added when the unit is in use.
6. When possible, biological samples should be fixed (usually with 1% formaldehyde) before being run through the flow cytometer.
7. For infectious, pathogenic and/or toxic materials, flow cytometry must be conducted in a certified chemical fume hood, certified biological safety cabinet or other negative exhaust ventilation system.

Section 11: Ethidium Bromide Handling and Disposal

Ethidium bromide, or EtBr, is commonly used 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 exposed to 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.

Handling

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).

Disposal

EtBr wastes are not regulated by the State of New Hampshire or the U.S. EPA. The wastes are prudently managed by laboratory staff and OEHS to minimize human and environmental exposure. Please follow the instructions listed in the following table when handling EtBr.

Ethidium Bromide Waste Disposal Procedures		
WASTE STREAM	**DESCRIPTION**	**WASTE DISPOSAL PROCEDURE**
Aqueous solutions	Typically contains very small concentrations of ethidium bromide. Normally <0.5 mg/L.	Dispose as hazardous waste. **If filtration systems are used, the spent filter must be disposed as hazardous waste.**
Stock Solutions	Typically contains higher concentrations of ethidium bromide. Approximately 10 mg/mL.	Dispose as hazardous waste in original container.
Gels	Typically contains 3-5 mg/L of ethidium bromide.	**Small quantity:** Dispose in a biohazard bag and place in a Stericycle biohazard box. **Large quantity:** Collect in 5-gallon plastic pails (provided by OEHS).
Contaminated Debris	Material contaminated with ethidium bromide (e.g. waste from spills, filters, gloves, etc.)	Dispose in a biohazard bag and place in a Stericycle biohazard box.
Crystals and Powders	Concentrated or pure ethidium bromide.	Dispose in a biohazard bag and place in a Stericycle biohazard box.
Note: When handling EtBr, always wear a laboratory coat, nitrile gloves and chemical splash goggles. When working with an ultraviolet (UV) light source, be sure to wear proper skin and eye protection. Avoid exposing unprotected skin and eyes to intense UV sources. Wear a face shield if UV source is pointing upwards. When working with a UV source for a long period of time, wrap up lab coat sleeves with tape or other means where the wrist could be exposed.		
Studies have shown that treatment with hypochlorite solutions does little to diminish the mutagenic properties of ethidium bromide. Contact the Hazardous Waste Coordinator for additional information at 862-3526.		

Section 12: 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.

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.

Materials to be Handled Using Universal Precautions

Universal precautions apply to blood, other body fluids containing visible blood, semen and vaginal secretions. Universal precautions also apply to tissues and to the following fluids: cerebrospinal, synovial, pleural, peritoneal, pericardial and amniotic fluids. Universal precautions do not apply to feces, nasal secretions, sputum, sweat, tears, urine and vomitus 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 Statistics

AIDS: At the end of 2004, the CDC estimated that 944,306 U.S. residents are living with HIV infection, with one-quarter of those unaware of HIV status.

Hepatitis B (HBV): The CDC estimates that the number of new infections per year has declined from an average of 260,000 in the 1980s to about 78,000 in 2001. This decline is thought to be associated with routine hepatitis B vaccination.

Personal Protective Equipment

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.

Section 13: Autoclave Maintenance and Testing

To insure sterility of materials and adequate decontamination of wastes, it is important for all departments to maintain autoclaves and to train personnel in their proper use. All autoclaves on campus should be checked monthly with chemical strips or by spore testing to make sure they are operating properly and the procedures are adequate for the decontamination of biohazardous waste (see **Appendix G**). A record of decontamination must be kept.

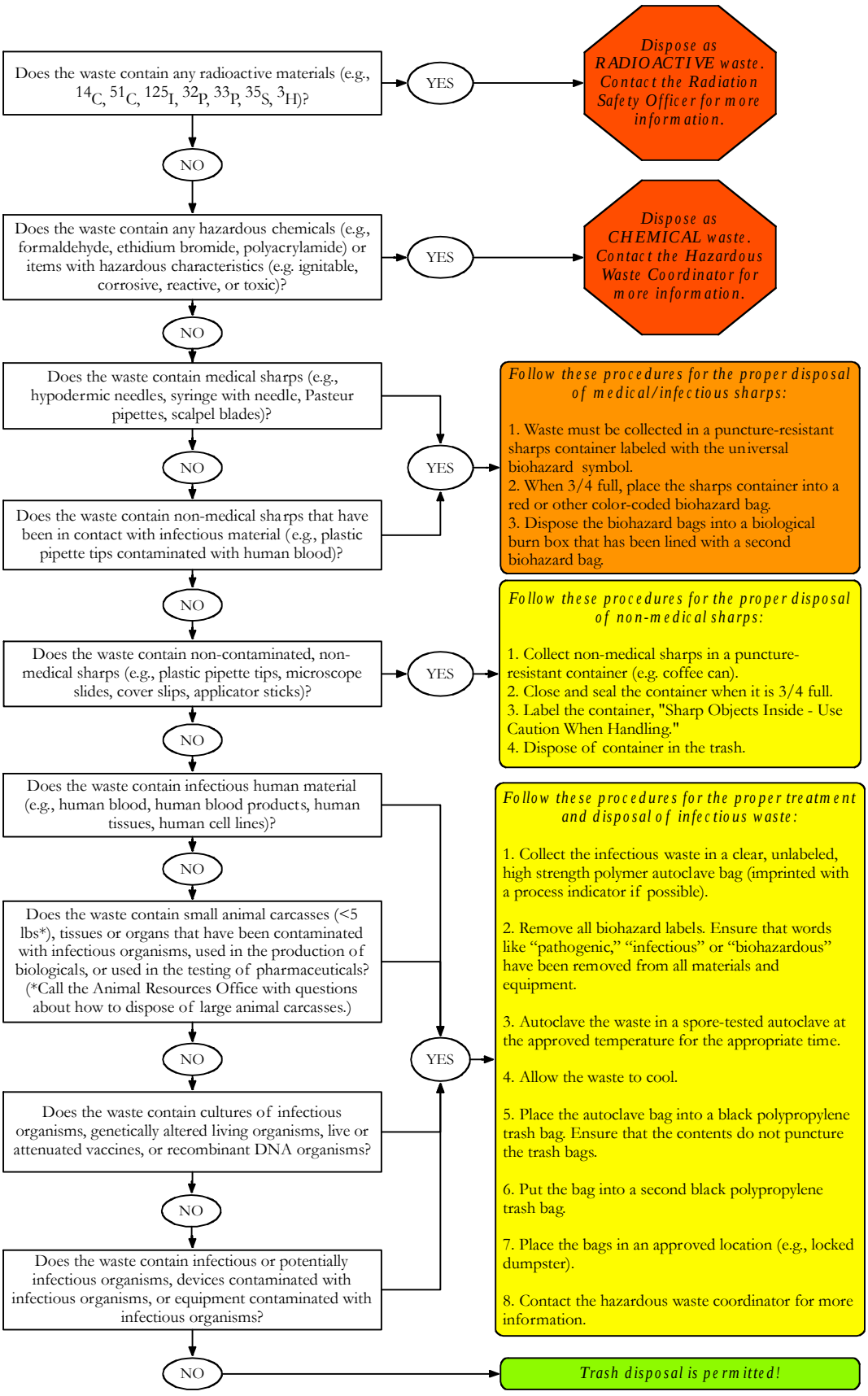
Section 14: Biohazardous Waste Disposal Practices

Biohazardous wastes generated during experiments should be placed in covered and labeled (biohazard label) containers or in a bag within a secondary container. Care should be taken to place all needles and syringes and other sharps in puncture proof containers. These "**sharps containers**" are available in your department (see **Chapter 2 – Laboratory Equipment** **or** **Appendix F**).

All biohazardous waste must be decontaminated by autoclaving, chemical disinfection or incineration (see **Appendices I – M**). Once this material has been properly decontaminated by autoclaving or chemical disinfection, it may be disposed as regular trash. There are very strict rules that apply to the disposal of "treated" infectious waste. **Use the flowchart on the next page to help determine the proper disposal method.** Contact OEHS before disposing this waste into the regular trash.

Important: Biohazard labels must be removed from decontaminated material before disposal with regular trash. Notify OEHS for disposal of sharps containers and incineration of biohazardous waste. If hazardous chemicals or radioactive materials are also present please consult OEHS before treatment and disposal.

Infectious Waste Disposal Flowchart



Chapter 11 – Radiation Safety

Section 1: Radiation Safety Program

Section 1: Radiation Safety Program

OEHS has a Radiation Protection Program, available on the OEHS website at http://www.unh.edu/ehs/pdf/RPP.pdf, which operates under the authority of the Radiation Safety Committee. This program assures compliance with the State of New Hampshire's agreement with the Nuclear Regulatory Commission and State license (190R) to use radioactive materials. OEHS provides a range of radiation protection services, including training of laboratory personnel, inventory of all radioisotopes used on campus, receipt and delivery of all radioactive material and waste pickup and disposal. For more information contact the Radiation Safety Officer at 862-3607.

Chapter 12 – Laser Safety

Section 1: Introduction

This document presents guidelines to protect University of New Hampshire (UNH) faculty, staff, students, and visitors from the hazards associated with lasers and laser system operations. The intent of this manual is to ensure the safe use of lasers through engineering and administrative controls. This objective shall be accomplished by identifying potential hazards, providing recommendations for hazard control, and training laser operators and incidental personnel. The recommendations and requirements detailed in this program are applicable to all lasers used in research and instructional laboratories operated by the University of New Hampshire.

This document provides guidance for compliance with applicable State and Federal regulations along with the American National Standard for the Safe Use of Lasers, ANSI Z136.1-2000 and is recognized as a minimum standard for laser safety.

Section 2: Responsibilities

Laser Safety Officer (LSO)

1. Conduct periodic laboratory/facility inspections to ensure that safety requirements are being met.
2. Provide assistance in evaluating and controlling beam and non-beam hazards.
3. Recommend laser safety controls including administrative, engineering, and personal protective equipment.
4. Maintain records of laser locations and owners.
5. Conduct and/or coordinate laser safety training for laser operators and other incidental personnel.
6. Investigate accidents involving lasers.
7. Update the Laser Safety Program as needed.

Principal Investigator

1. Register all lasers with LSO by completing a Laser Registration Form (see **Section 7**) for each laser within the laboratory.
2. Provide immediate supervision of laser use.
3. Maintain an up-to-date list of all laser operators in the laboratory.
4. Provide, implement, and enforce the safety recommendations and requirements described in this program.
5. Maintain a written standard operating procedure for laser use.
6. Provide training in the administrative, alignment, and standard operating procedures for laser users.
7. Attend laser safety training provided or coordinated by the LSO.
8. Notify LSO immediately in the event of an exposure to a Class IIIb or IV laser.

Laser Operator Responsibilities

1. Follow laboratory administrative, alignment, and standard operating procedures.
2. Keep the Principal Investigator fully informed of any departure from established safety procedures including all exposure incidents.
3. Attend the laser safety training program provided or coordinated through LSO.

Ancillary Personnel Responsibilities

1. Recognize and adhere to the laboratory signage and written safety protocols.
2. Attend laser safety awareness training for incidental personnel.
3. Do not enter areas that contain unfamiliar equipment.

Section 3: Laser Safety Fundamentals

A. Laser Classification

Lasers are divided into a number of classes depending upon the power or energy of the beam and the wavelength of the emitted radiation. Laser classification is based on the laser's potential for causing immediate injury to the eye or skin and/or potential for causing fires from direct or indirect exposure. Commercially produced lasers have been classified and identified by labels affixed to the laser since August 1, 1976. In cases where the laser has been fabricated on campus or is otherwise not labeled, the LSO will assist with properly classifying and labeling the laser. Lasers are classified using physical parameters of the laser including power, wavelength, and exposure duration.

1. Class I Lasers

- Not capable of producing damaging radiation levels during operation or maintenance.
- Class I lasers are sealed in an enclosure that prohibits or limits access to the laser radiation (e.g., a laser printer).
- Exempt from control measures.

2. Class II Lasers

- All Class II lasers operate within the visible region of the spectrum (400-700nm).
- Output is not intended to be viewed (e.g., a grocery scanner).
- Eye protection is normally afforded by the aversion response (i.e., blink reflex) to bright light.
- Upper power limit for Class II continuous wave (CW) lasers is 1 mW.

3. Class IIIa Lasers

- Power output is up to 5 times greater than Class II (5mW).
- Laser or laser systems that would not normally produce a hazard if viewed for only a moment with the unaided eye (e.g., a laser pointing device).
- Beams may present a hazard if viewed through collecting optics.
- Class IIIa lasers should have a "Caution" sign posted on the outside of the door.

4. Class IIIb Lasers

- Maximum power output is less than 500 mW.
- CW lasers operate between the upper Class IIIa limits (5mW) and the maximum power for Class IIIb lasers (500 mW).
- Diffuse reflections are usually not hazardous. However, lasers or laser systems may produce a hazard if viewed directly through intrabeam viewing or specular reflections.
- Class IIIb lasers shall have a "Danger" sign posted on the outside of the door.

5. Class IV Lasers

- Power exceeds Class IIIb limits of 500mW.
- High-powered lasers and laser systems capable of causing severe eye damage with short duration exposures (<0.25 seconds) to the direct, specularly, or diffusely reflected beam.
- Capable of causing severe skin damage.
- Can ignite flammable and combustible materials.
- May produce laser generated air contaminants or hazardous plasma radiation.
- Class IV lasers shall have a "Danger" sign posted on the outside of the door.

B. Laser Registration

The Principal Investigator is responsible for all safety precautions pertaining to the laser systems described in this manual. A Laser Registration Form (see **Section 7**) **should** be filled out for each Class IIIa laser and/or laser system and **must** be filled out and returned to the LSO for each Class IIIb, and Class IV laser and/or laser system used at UNH.

Any changes in the use of the laser, laser location, and/or transfer of a laser require LSO notification. The Laser Relocation Form (see **Section 8**) must be filled out and faxed to the LSO (862-0047) prior to moving a laser or laser system. If you have any questions about completing the laser registration form or relocation form, please contact the OEHS at 862-4041 or send an email to ehs@unh.edu.

C. Laser Hazards

1. Beam Hazards

The Eye

The eye is extremely vulnerable to injury if exposed to laser beams. The type of injury depends upon the intensity of light, its wavelength, and the tissue being exposed. Damage results from either temperature or photochemical effects. Acute exposure may result in corneal or retinal burns. Cataract formation or damage to the retina may result from chronic exposure to laser light. Retinal damage is of particular concern from exposure to wavelengths in the visible and near infrared region.

Most sources of incoherent light can be viewed safely because the light reaching the eye is only a small portion of the total output and the energy is spread over the entire retina. Laser radiation, however, is composed of coherent light. The beam can pass through the pupil and focus on a very small spot on the retina, depositing all its energy on this area. Only visible and near infrared radiation is focused on the retina. Damage to the retina may result in limited or total blindness if the optic nerve is injured. Injury may be irreversible and there may be no pain or discomfort from the exposure.

The Skin

Skin damage is also possible from exposure to laser beams. Acute exposure may cause injuries ranging from mild reddening to blistering and charring. Skin cancers may result from chronic exposure to ultraviolet light. The extent and type of damage depends on the amount of energy deposited and the wavelength of the light. Unlike injury to the eye, acute damage to the skin is usually repairable.

Biological Effects of Lasers		
Spectral Wavelength	**Eye Damage**	**Skin Damage**
Ultraviolet C (200nm – 280nm)	Photokeratitis	Erythema, skin cancer, accelerated skin aging
Ultraviolet B (280nm – 315nm)	Photokeratitis	Increased pigmentation
Ultraviolet A (315nm – 400nm)	Photochemical cataract	Pigment darkening, skin burn
Visible (400nm – 780nm)	Photochemical and thermal retinal injury	Pigment darkening, photosensitive reactions, skin burn
Infrared A (780nm – 1400nm)	Cataract and retinal burn	Skin burn
Infrared B (1.4μm – 3.0μm)	Corneal burn, aqueous flare, cataract	Skin burn
Infrared C (3.0μm – 1000μm)	Corneal burn	Skin burn

There are a variety of types of beam exposures that are not limited to intrabeam viewing. For high-powered lasers, the specular or diffuse reflection may be equally as damaging.

Intrabeam exposure: The skin or eye is exposed directly to all or part of the laser beam resulting in a full exposure to the irradiance of the beam.

Specular reflection: The reflection from a smooth or mirrored surface. Items such as jewelry or cover glass of wristwatches produce specular reflections. These items should be removed prior to operating a laser. Exposure to specular reflections can be as equally dangerous as an intrabeam viewing.

Diffuse reflection: Reflection of a non-uniform or rough surface. Diffuse reflection scatters the beam and does not carry the full power of an intrabeam. However, diffuse reflections from Class IV lasers can contain enough power to initiate a fire.

2. Non-Beam Hazards

In addition to the beam hazards of a laser, other hazards may be associated with its operation. These non-beam hazards include electrical shock, explosions, flammable liquids, compressed gases, noise, UV radiation, dyes, solutions, and laser generated air contaminants. Safety considerations that may go into the assessment and evaluation of laser hazards include electrical, skin exposure, chemical and associated gas hazards. Some other special considerations include whether the laser is enclosed in an engineered system of protection, the beam is invisible, whether maintenance, repair, and/or modifications will be necessary on a routine basis, and whether there is a potential for explosion, fire, or hazardous fumes.

Electrical

Electrical hazards pose the most significant risk among the non-beam hazards. Several accidents within the U.S. have resulted in electrocution. To reduce electrical hazards, high voltage sources and terminals must be enclosed unless the work area is restricted to qualified persons only. Whenever feasible, power must be turned off and all high-voltage points grounded before working on power supplies. Capacitors must be equipped with bleeder resistors, discharge devices, or automatic shorting devices. Other general electrical guidelines include:

- Never wear jewelry when operating a laser. Metal jewelry can be conductive. Jewelry in general can create a specular reflection hazard. This includes wristwatches.
- Use the one hand rule when working on circuits.
- Avoid standing in water and assume that all floors are conductive when working with high voltage.

- Use rubber gloves and insulating floor mats when available.
- Do not work alone.
- Maintain access to main power shutoff.

It is good practice to have at least one person in the work area that is trained and certified in cardiopulmonary resuscitation (CPR) in the event that this form of first aid is needed.

Explosions

Lasers and ancillary equipment may present explosion hazards. High pressure arc lamps and filament lamps used to excite the lasing medium must be enclosed in housings that can withstand an explosion if the lamp disintegrates. In addition, the laser target and elements of the optical train may shatter during laser operation and should be enclosed in a suitable protective housing. Capacitors may explode if subjected to voltages higher than their rating and must be adequately shielded; it is recommended that capacitors be equipped with current-limiting devices. High-energy capacitors should be enclosed in one-eighth inch thick steel cabinets.

Flammables

A Class IV laser beam may ignite flammable solvents, gases, and combustible materials. A non-combustible material, such as a brick, should be used to terminate laser beams. Combustible solvents or materials should be stored in proper containers and shielded from the laser beam or electrical sparks. Lasers and laser facilities should be constructed and operated to eliminate or reduce any fire hazard. Unnecessary combustible materials should be removed in order to minimize fire hazards. Laser laboratories should contain an appropriate fire extinguisher.

Compressed Gases

Many hazardous gases are used in lasers including chlorine, fluorine, hydrogen chloride, and hydrogen fluoride. A standard operating procedure should be developed for the safe handling of compressed gases. Some safety issues to consider are:

- Cylinders cannot be free standing. They must be attached to a cart or secured by a chain or strap.
- Gases of different categories (toxics, corrosives, flammables, oxidizers) must be stored separately.

Noise

Noise levels in laser laboratories can exceed safe limits because of high voltage capacitor discharges. Hearing protection may be required. The LSO will provide a noise survey to determine whether noise levels exceed safe limits.

UV Radiation

Laser discharge tubes and pumping tubes may emit hazardous levels of ultraviolet radiation called "collateral UV" and should be suitably shielded. UV radiation can cause photodermatitis as a result of exposure to some industrial chemicals or medications.

Laser Dyes and Solutions

Laser dyes are complex fluorescent organic compounds, which, in solution with certain solvents, form a lasing medium for dye lasers. Certain dyes are highly toxic or carcinogenic. These dyes are frequently changed and special care must be taken when handling, preparing solutions, and operating dye lasers. A Material Safety Data Sheet for dye compounds shall be made available to all appropriate workers.

Laser Generated Air Contaminants (LGAC)

Air contaminants may be generated when certain Class IIIb and Class IV laser beams interact with matter. The quantity, composition, and chemical complexity of the LGAC depend greatly upon the target material, cover gas, and beam irradiance. The LSO will ensure that the industrial hygiene aspects of exposure to LGAC are addressed and that the appropriate control measures are used.

Section 4: Engineering Controls

Engineering controls are the primary means of minimizing the possibility of accidental exposures to laser hazards. If engineering controls are impractical or inadequate, then safety should be supported through the use of administrative procedures and personal protective equipment. Engineering controls that may prove useful and effective in improving the safety of a laser or laser system are listed below.

A. Protective Housing and Interlocks

A protective housing is a physical barrier sufficient to contain the beam and laser radiation from exiting the laser system so that the maximum permissible exposure (MPE) is not exceeded on the outside surface. Protective housings must be interlocked so that the laser cannot operate when the housing is opened or removed. When the requirements of a protective housing are fulfilled, the laser system is considered a Class I laser and no further control measures are required.

B. Laser Use Without Protective Housing

In the research environment, lasers are often used without a protective housing in place. The use of optical tables and optical devices are typically employed in order to manipulate the laser beam. The LSO will evaluate the hazards and recommend control measures to ensure safe operation in this environment. These control measures may include but are not limited to the following:

- Access restriction.
- Area controls.
- Barriers, curtains, and beam stops.
- Procedural controls.
- Eye protection.
- Training.

C. Access Restriction

For Class IIIb and Class IV laser laboratories, access controls are required to prevent unauthorized personnel from entering the area when the laser is in use. Doors must be kept closed when the laser is in operation. Secondary doors that can allow access to a laser in operation must be either locked or posted similarly to the primary entrance.

D. Area Control

Class IIIb and Class IV laser area control measures are used to minimize laser radiation hazards. The area must be posted with the appropriate signage and include a lighted sign at the doorway indicating the "on" status of a laser system. Only authorized personnel who have been appropriately trained will be allowed to operate the laser. Control of the laser beam path shall be accomplished in the following manner:

Totally Unenclosed Beam Path

Where the entire beam path is unenclosed, a laser hazard analysis shall be performed by the LSO to establish the nominal hazard zone (NHZ) if not furnished by the manufacturer or available as part of the classification.

Limited Open Beam Path

Where the beam path is confined to significantly limit the degree of accessibility of the open beam, a hazard analysis shall be performed by the LSO to establish the NHZ.

Enclosed Beam Path

When the protective housing requirements are temporarily relaxed, such as during service, the LSO shall establish the appropriate controls. These may include a temporary area control and administrative and procedural controls.

E. Barriers, Enclosures, and Beam Stops

Beam barriers, enclosures, and stops are used to prevent beam propagation outside of the controlled access area in excess of the MPE. It is always desirable to enclose as much of the beam path as possible. As with a protective housing, the proper enclosure of the entire beam path may change the laser system to a Class 1 laser. When the beam needs to be directed to another area, such as between optical tables, enclosure of the beam is recommended. Physical barriers are used to prevent laser radiation from exiting the controlled area. Laser curtains and partitions are routinely used as laser containment systems. Rail curtains can be used to completely enclose an optical table or part of the laser system. Due to the power density of Class IV lasers, the combustible properties of the barrier material must be evaluated. Beam stops are used to prevent the beam from leaving the optical table and to terminate the beam path. Beam stops are to be used behind optical devices in the event that the beam becomes misaligned.

Section 5: Administrative Controls

A. Standard Operating Procedures (SOPs)

A written SOP must be established for all Class IV lasers and should be established for all Class IIIb lasers for normal, maintenance, and alignment operations. The SOPs will be maintained with the laser equipment for reference by operators or service personnel and can be used for instructional material to train new laser users in the laboratory. All SOPs will be updated to reflect any changes in laboratory protocol and equipment usage.

B. Warning Signs and Labels

All signs and labels must comply with ANSI Z136.1-2000. Entryways into laboratories containing Class IIIa lasers should be posted with a “Caution” sign. Entryways into laboratories containing Class IIIb and Class IV laser shall be posted with a "Danger" sign. The signs shall include the type of laser (i.e., Nd:YAG, Helium Neon), the emitted wavelength, maximum output, and class (see Appendix F). All lasers classes except Class I shall have appropriate equipment warning labels affixed to a conspicuous place on the laser housing or control panel.

Summary of the Engineering, Administrative, and Procedural Control Measures					
	I	**II**	**IIIa**	**IIIb**	**IV**
Engineering Control Measures					
Protective housing	X	X	X	X	X
Without protective housing	LSO shall establish alternative controls				
Interlocks on protective housing	*	*	*	X	X
Service access panel	*	*	*	X	X
Key controls				O	X
Viewing portals		MPE	MPE	MPE	MPE
Collecting optics	MPE	MPE	MPE	MPE	MPE
Established NHZ for open beam				X	X
Limited open beam path				X	X
Remote interlock connector				O	X
Beam stop or attenuator				O	X
Activation warning signal				O	X
Emission delay					X
Classification and warning labels	X	X	X	X	X
Area posting			O	X NHZ	X NHZ
Laser control area				X	X
Temporary laser control area	* MPE	* MPE	* MPE		
	I	**II**	**IIIa**	**IIIb**	**IV**
Administrative and Procedural Control Measures					
Eye protection				MPE	X
Determine authorized personnel				X	X
Standard Operating Procedures				O	X
Spectator control				O	X
Education and Training		O	O	X	X
Service Personnel	MPE	MPE	MPE	X	X

Legend:

X = Shall
O = Should
MPE = Shall if MPE is exceeded
* = Shall if enclosed IIIb or IV Laser
NHZ = Nominal Hazard Zone analysis required

Section 6: Personal Protective Equipment

A. Eye Protection

Eye protection is required for Class IIIb and IV lasers when engineering and administrative controls are inadequate to eliminate potential exposure in excess of the applicable MPE. The use of laser protective eyewear is especially important during alignment procedures since most laser accidents occur during this process. Protective eyewear must be labeled with the absorption wavelength and optical density (OD) rating at that wavelength.

The LSO will determine the proper OD for protective eyewear through the following:

1. Determine Maximum Permissible Exposure (MPE) limit

- Visible beams (400-700nm) = 0.25 seconds (aversion response to light)
- Infrared beams (760-1mm) = 10 seconds (aversion response to heat)
- Ultra-violet beams (100-400nm) = Maximum on time of laser (up to 8 hours)
- MPE Limit is established through Table 5a ANSI Z136.1

2. Determine the maximum Irradiance (E) in Watts/cm^2

- E = Laser output in Watts / Area of limiting aperture [eye lens has diameter ~ 0.7 cm, hence Area = 0.8 x $(0.7cm)^2$ = $0.39cm^2$]

3. Calculate the Optical Density (Dλ)

- OD (Dλ) = $\log_{10}$ (E / MPE)

In addition to selecting the appropriate OD for safe viewing, one should consider the percent of visible light transmitted to the eye while wearing eye protection so that the beam can be adequately seen without the need to remove the protective eyewear. Comfort and fit are also important factors when selecting protective eyewear.

B. Skin Protection

Skin exposure can be of significant importance with the use of lasers emitting in the ultraviolet spectral region. The potential for skin injury from the use of high power lasers can present a potential hazard. For laser systems using an open beam, skin protection may be necessary. Covering exposed skin by using lab coats, gloves and an UV face shield will protect against UV scattered radiation. Adequate skin protection may be required for certain applications using high power laser systems.

Section 7: Laser Registration Form

Please complete (1) form for each laser and fax (862-0047) to Laser Safety Officer

Principal Investigator: _____ Phone #: _____

Email: _____ Title: _____

Department: _____

Building where laser is located: _____ Room #: _____

Please list all laser users/operators: _____

_____

_____

Laser Identification Information

Laser Manufacturer: _____ Model Number: _____

Serial Number: _____ Laser Type (e.g., Nd:YAG, Ar): _____

*Class I ___ *Class II ___ Class IIIa ___ Class IIIb ___ Class IV ___
(*Please indicate whether there is an enclosed Class IIIa, IIIb, or IV laser)

Optical Characteristics

Wavelength (nm): _____ Type (CW or Pulsed): _____

For CW Lasers, Average Power = _____ For Pulsed Lasers, Peak Power = _____

General Information

Have all operators/users received training?	Yes _____ No _____
Has the training been documented?	Yes _____ No _____
Have laboratory Standard Operating Procedures and Safety Guidelines been established for the use of the laser?	Yes _____ No _____

Laser Safety Checklist

A. Does the door have the proper sign?	Yes _____ No _____
B. Is equipment labeled with laser parameters?	Yes _____ No _____
C. Is access to the room controlled?	Yes _____ No _____
D. Are warning devices used when laser is energized?	Yes _____ No _____
E. Are system interlocks used?	Yes _____ No _____
F. Is proper eye protection provided?	Yes _____ No _____
G. Is there adequate room illumination?	Yes _____ No _____
H. Are reflective surfaces in the room controlled?	Yes _____ No _____
I. Are elements in the beam path secured?	Yes _____ No _____
J. Date of Last Inspection: _____	
K. Other Comments: _____	

_____

Principal Investigator Signature: _____

Date: _____

Section 8: Laser Relocation Form

Please complete (1) form for each laser and fax (862-0047) to Laser Safety Officer

Principal Investigator: _____ Phone #: _____

Email: _____ Title: _____

Department: _____

Building where laser is currently located: _____ Room #: _____

Please list all laser users/operators: _____

_____

_____

Laser Identification Information

Laser Manufacturer: _____ Model Number: _____

Serial Number: _____ Laser Type (e.g., Nd:YAG, Ar): _____

*Class I ___ *Class II ___ Class IIIa ___ Class IIIb ___ Class IV ___
(*Please indicate whether there is an enclosed Class IIIa, IIIb, or IV laser)

Laser Location - Please check one below

_____ The laser/laser system identified above will remain in its current location.
OR
_____ The laser/laser system identified above is being relocated to:

Building: _____ Room #: _____

NOTE: If laser is moving to another department or leaving UNH completely, please explain below: _____

_____

_____

Principal Investigator Signature: _____

Date: _____

Section 9: Laser Exposure Incident Report

Please complete (1) form for each laser and fax (862-0047) to Laser Safety Officer

Name of exposed individual: _____

Status (student, staff, faculty, visitor, etc.): _____

Date of incident: _____ Time of incident: _____

Location of facility where exposure occurred: _____

Type of laser producing exposure (HeNe, Nd:YAG, etc.): _____ Class: IIIa IIIb IV

Name of person whom registered laser: _____

Supervising or witnessing individuals: _____

Nature of exposure: _____

Eye Exposed: Left only _____ Right only _____ Both _____

Skin location: _____

Duration: minutes _____ seconds _____

Describe the exposure circumstances (work being performed): _____

_____

_____

How was the incident caused? _____

_____

_____

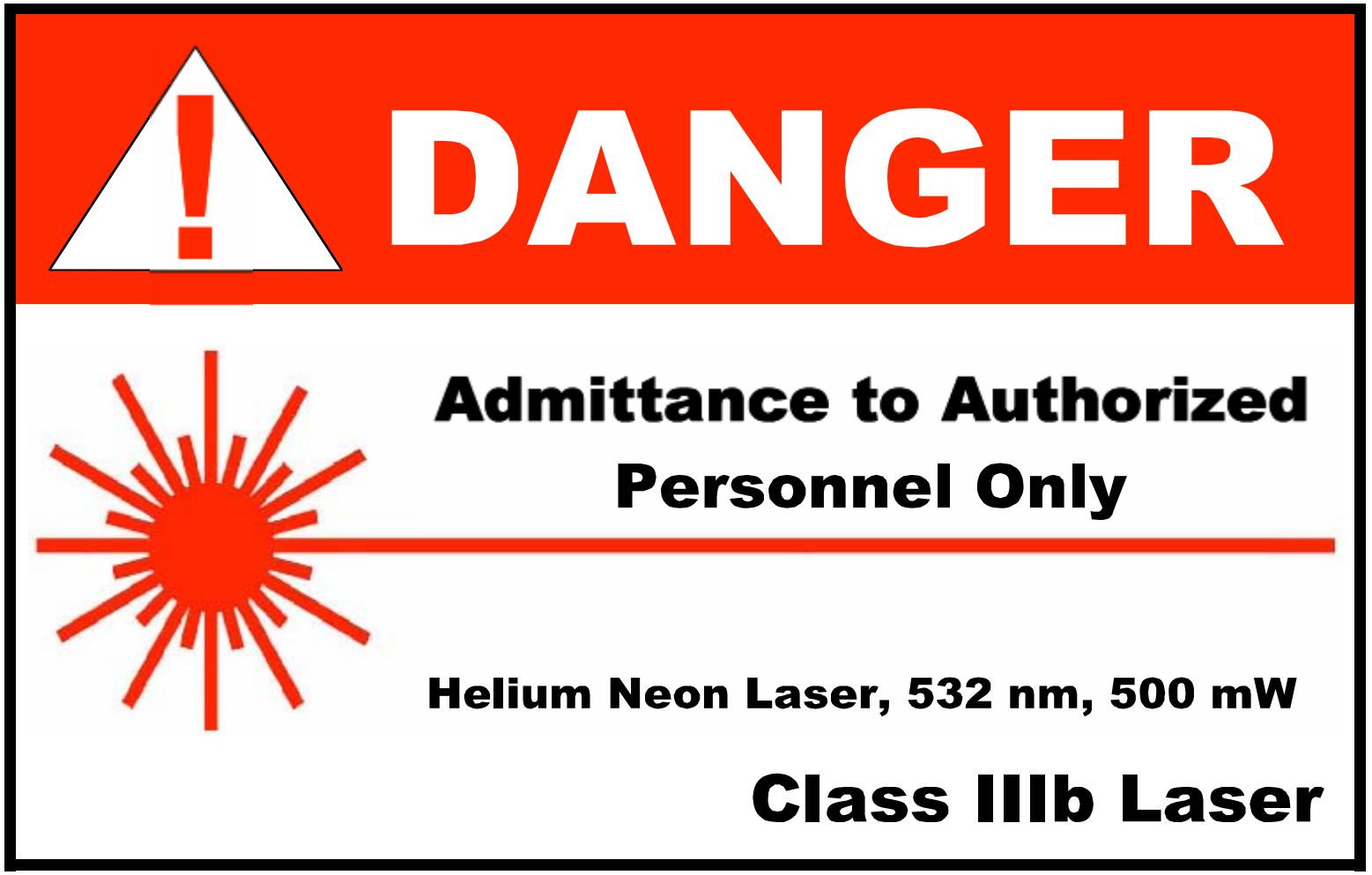
Personal protective equipment being used at the time of exposure: _____

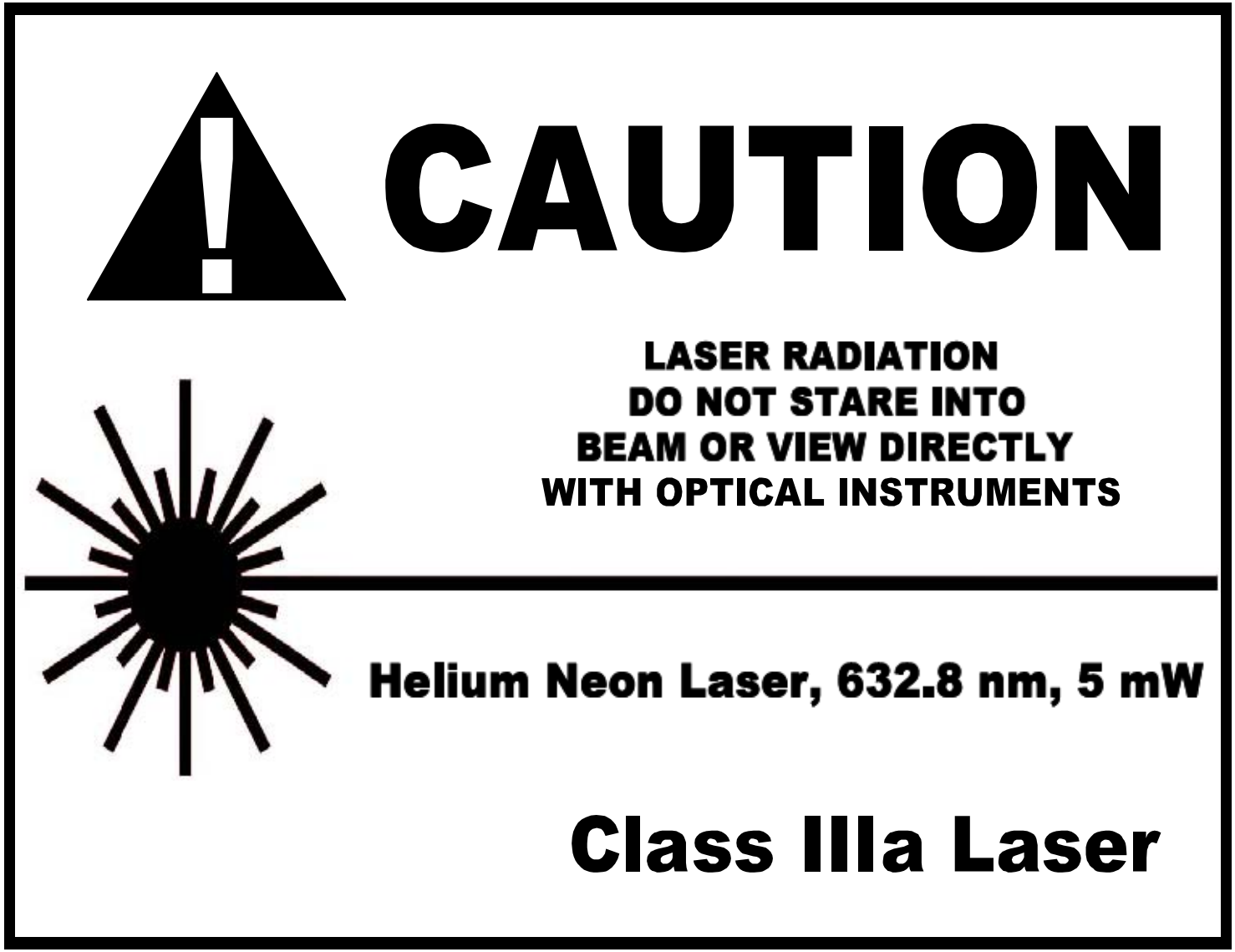
_____

Did you seek medical attention? Yes _____ No _____

Name of Person Completing Form: _____

Date: _____


DANGER
Admittance to Authorized
Personnel Only
Helium Neon Laser, 532 nm, 500 mW
Class IIIb Laser


CAUTION
LASER RADIATION
DO NOT STARE INTO
BEAM OR VIEW DIRECTLY
WITH OPTICAL INSTRUMENTS
Helium Neon Laser, 632.8 nm, 5 mW
Class IIIa Laser

Section 11: Glossary of Terms

The following terms are used in the Laser Safety section of this document:

Absorption: Transformation of radiant energy to a different form of energy by interaction with matter.

Aperture: An opening through which radiation can pass.

Attenuation: The decrease in the radiant flux as it passes through an absorbing or scattering medium.

Average Power: The total energy imparted during exposure divided by the exposure duration.

Aversion Response: Closure of the eyelid, or movement of the head to avoid an exposure to a noxious stimulant or bright light. In this standard, the aversion response to an exposure from a bright laser source is assumed to occur within 0.25 s, including the blink reflex time.

Authorized Laser Operator: An individual who has been trained in laser safety and laser operating procedures.

Beam: A collection of rays which may be parallel, divergent, or convergent.

Beam Diameter: The diameter of that portion of the beam which contains 86% of the output power.

Blink Reflex: See Aversion response.

Carcinogen: An agent potentially capable of causing cancer.

Coherent: Radiation composed of wave trains vibrating in phase with each other. Simply expressed: parallel rays of light.

Continuous Wave (CW): The output of a laser, which is operated in a continuous rather than pulsed mode. In this standard, a laser operating with a continuous output for a period > 0.25 s is regarded as a CW laser.

Controlled Area: An area where the occupancy and activity of those within is subject to control and supervision for the purpose of protection from radiation hazards.

Cornea: The transparent outer coat of the human eye that covers the iris and the crystalline lens. The cornea is the main refracting element of the eye.

Diffraction: Deviation of part of a beam, determined by the wave nature of radiation and occurring when the radiation passes the edge of an opaque obstacle.

Diffuse Reflection: Change of the spatial distribution of a beam of radiation when it is reflected in many directions by a surface or by a medium.

Divergence: The angle at which the laser beam spreads in the far field; the bending of rays away from each other, as by a concave lens or convex mirror. Sometimes this is also referred to as beam spread.

Electromagnetic Radiation: Includes radio waves; X-rays; gamma rays; and infrared, ultraviolet, and visible light. The flow of energy consisting of electric and magnetic fields lying transverse to the direction of propagation. X ray, ultraviolet, visible, infrared, and radio waves occupy various portions of the electromagnetic spectrum and differ only in frequency, wavelength, or photon energy.

Enclosed Laser: A laser that is contained within a protective housing of itself or of the laser or laser system in which it is incorporated. Opening or removal of the protective housing provides additional access to laser radiation above the applicable MPE than possible with the protective housing in place. (An embedded laser is an example of one type of enclosed laser.)

Energy: The capacity for doing work. Energy content is commonly used to characterize the output from pulsed lasers, and is generally expressed in joules (J).

Erythema: Redness of the skin due to congestion of the capillaries.

Extended Source: An extended source of radiation that can be resolved into a geometrical image in contrast with a point source of radiation, which cannot be resolved into a geometrical image. A light source whose diameter subtends a relatively large angle from an observer.

Failsafe Interlock: An interlock where the failure of a single mechanical or electrical component of the interlock will cause the system to go into, or remain in, a safe mode.

Hertz (Hz): The unit that expresses the frequency of a periodic oscillation in cycles per second.

Infrared Radiation: Electromagnetic radiation with wavelengths that lie within the range 0.7 μm to 1 mm.

Intrabeam Viewing: The viewing condition whereby the eye is exposed to all or part of the laser beam.

Ionizing Radiation: Electromagnetic radiation having sufficiently large amount of photon energy to directly ionize atomic or molecular systems with a single quantum event.

Irradiance (E): The power emitted per unit area upon a surface; expressed in watts per square centimeter (W/cm2).

Joule: A unit of energy. 1 joule = 1 watt · second.

Laser: A laser is a cavity, with mirrors at the ends, filled with material such as crystal, glass, liquid, gas or dye. A device which produces an intense beam of light with the unique properties of coherency, collimation and monochromaticity. An acronym for Light Amplification by Stimulated Emission of Radiation.

Laser Safety Officer (LSO): One who has authority to monitor and enforce the control of laser hazards and effect the knowledgeable evaluation and control of laser hazards.

Laser System: An assembly of electrical, mechanical, and optical components that includes a laser.

Maximum Permissible Exposure (MPE): The level of laser and radiation to which a person may be exposed without hazardous effect or adverse biological changes to eye or skin. MPE is expressed in terms of either radiant exposure (Joules/cm2) or irradiance (Watts/cm2). The criteria for MPE is detailed in Section 8 of ANSI Z136.1.

Maintenance: Performance of those adjustments or procedures specified in user information provided by the manufacturer with the laser or laser system, which are to be performed by the user to ensure the intended performance of the product. It does not include operation or service as defined in this section.

Nominal Hazard Zone (NHZ): A zone that describes the space within which the level of the direct, reflected, or scattered radiation during normal operation exceeds the applicable MPE. Exposure levels beyond the boundary of the NHZ are below the appropriate MPE level.

Operation: The performance of the laser or laser system over the full range of its intended functions (normal operation). It does not include maintenance or service as defined in this section.

Optical Density (OD): A logarithmic expression for the attenuation of the irradiation produced by an attenuating medium, such as an eye protection filter.

Photosensitizers: Substances that increase the sensitivity of a material to irradiation by electromagnetic energy.

Point Source: Ideally, a source with infinitesimal dimensions. Practically, a source of radiation whose dimensions are small compared with the viewing distance. For the purpose of this standard, a point source leads to intrabeam viewing condition.

Power: The rate at which energy is emitted, transferred, or received. Unit: watts (joules per second).

PRF: Abbreviation for Pulse Repetition Frequency.

Protective Housing: An enclosure that surrounds the laser or laser system that prevents access to laser radiation above the applicable MPE level. The aperture through which the useful beam is emitted is not part of the protective housing. The protective housing may enclose associated optics and a workstation and shall limit access to other associated radiant energy emissions and to electrical hazards associated with components and terminals.

Pulse Duration: The duration of a laser pulse; usually measured as the time interval between the half-power points on the leading and trailing edges of the pulse.

Q-Switched Laser: A laser that emits short (<30 ns), high-power pulses by means of a Q-switch.

Repetitive Pulsed Laser: A laser with multiple pulses of radiant energy occurring in sequence with a pulse repetition frequency greater than or equal to 1 Hz.

Service: The performance of those procedures or adjustments described in the manufacturer's service or instructions which may affect any aspect of the performance of the laser or laser system. It does not include maintenance or operation as defined in this section.

Source: A laser or a laser-illuminated reflecting surface.

Specular Reflection: A mirror-like reflection.

Transmittance: The ratio of total transmitted radiant power to the total incident radiant power.

Ultraviolet Radiation (light): Electromagnetic radiation with wavelengths smaller than those of visible radiation; for the purpose of laser safety, 200nm to 400nm.

Visible Radiation (light): Electromagnetic radiation that can be detected by the human eye. This term is commonly used to describe wavelengths that lie in the range of 400nm to 700nm.

Watt: The unit of power or radiant flux. 1 watt = 1 joule / second.

Wavelength: The distance between two successive points on a periodic wave that are in phase.

Chapter 13 – Electrical Safety Plan

Section 1: Introduction

Section 2: Roles and Responsibilities

Section 3: General Requirements

Section 4: Use of Extension Cords

Section 5: Use of Power Strips

Section 6 Use of Clamp Lighting

Section 7: Ground Fault Circuit Interrupters

Section 8: Changes to Building Electrical Services

Section 9: Damaged or Defective Equipment

Section 10: Special Considerations

Section 1: Introduction

The purpose of this section is to inform laboratory occupants to remediate electrical hazards when possible and develop appropriate work procedures for electrical safety.

Electrical hazards for laboratory employees and students usually include shock, burn, or fire hazards. Electrical shocks occur when a part of the body becomes part of the electrical circuit. One way this can occur is by contacting a metallic part of a piece of equipment that has become energized by contact with an electrical conductor. The severity of the electrical shock depends on the following:

- The amount of the current (measured in Amperes or Amps);
- The pathway through the body;
- The duration of the exposure; and
- Whether the skin is wet or dry.

Section 2: Roles and Responsibilities

Facilities Design and Construction (FD&C) specifies electrical design standards for UNH. FD&C oversees the design of electrical systems in new buildings as well as renovations and changes to existing buildings. Facilities Maintenance in each of the zones is responsible for responding to maintenance requests made by laboratory personnel and fulfilling those requests in a manner that meets the design guidelines set forth by FD&C.

Laboratory personnel are responsible for their electrical equipment. Facilities Maintenance personnel may only perform design changes to the building's electrical infrastructure. Specific changes may be required when converting a dry laboratory to a wet environment or when a change in the electrical load exceeds the capacity in a given area (such as after a new laboratory is established in an existing space). Laboratory personnel are responsible for ensuring that electrical equipment connected to the building power system is in good condition.

The Office of Environmental Health and Safety (OEHS) provides electrical safety guidance for the University community. OEHS will respond to technical questions and provide individual assistance on electrical safety issues. OEHS inspects laboratories for electrical safety compliance and investigates all accidents resulting from electrical exposure. Any electrical accident of a serious nature would also be investigated by the State Fire Marshal and the State Electrical Inspector.

Section 3: General Requirements

Laboratory personnel typically encounter electricity in the form of hard-wired equipment (e.g. specialty microscopes, generators), plug-and-cord equipment (e.g. refrigeration, centrifuges, heating baths, electrophoresis devices), extension cords, and outlets. The following requirements must be followed to ensure electrical safety:

- All electrical equipment used by laboratories must be listed by a nationally recognized testing laboratory (NRTL), with a label showing its approval. It must be used in accordance with the instructions on the listing or labeling. Two

examples of NRTLs include Underwriter's Laboratory (UL) and Factory Mutual (FM). A full listing of approved NRTLs can be found on the OSHA website at: http://www.osha.gov/dts/otpca/nrtl/index.html.

- Work on electrical utilization systems may only be done by an electrician that is properly licensed in the State of New Hampshire. Under no circumstances may laboratory personnel undertake changes to the building electrical service.
- Laboratory personnel must always disconnect the power source to any electrical equipment before attempting non-electrical service or repair.
- Live parts of electrical equipment operating at 50 volts or more must be guarded against accidental contact.
- A minimum 36-inch clearance must be maintained around electrical controls, panels and disconnects at all times. Greater clearance distances may be required when the equipment voltage is greater than 150V in conjunction with certain workplace conditions. Contact OEHS for more information.
- When unplugging a device, be sure to pull from the plug to prevent wiring damage.
- Never override electrical safety equipment such as guards or electrical interlocks.

Section 4: Use of Extension Cords

In general, extension cords are not appropriate where a permanent wiring solution is available, regardless of convenience. Extension cords should be used only for temporary purposes and replaced with surge protectors if needed for longer periods of time. When extension cords are used, the following restrictions apply:

- Use only extension cords that are listed and labeled by a NRTL.
- Use only extension cords that are rated for hard or extra hard usage. The rating must be denoted not only on the original package but also printed on the extension cord insulating jacket. Review the capacity of the extension cord to ensure that you are staying within the cord's power rating.
- Use only extension cords with a minimum conductor size of 12 AWG (American Wire Gauge) and only cords with a grounding pin. Never remove the grounding pin to make a three prong cord fit in a two-prong outlet.
- Extension cords may not be run through doors, windows, walls, or ceilings and may not be attached to building surfaces (i.e. walls, ceilings) by staples or other means.
- Extension cords must be protected from damage and may not be placed in such a way that they create a tripping hazard.
- Extension cords may not be plugged in end-to-end or "daisy-chained."
- Extension cords must be inspected regularly for wear, as it is especially likely around the plug. Worn or frayed cords must be removed from service and replaced. Cracks in extension cords may not be repaired with electrical tape.

Section 5: Use of Power Strips

Power strips permit more products to be plugged into the same outlet. While power strips may be convenient they may also create safety hazards when used incorrectly. Power strips do not increase the amount of power available to a location, but rather more access to the same electrical source. A heavy reliance on power strips generally

indicates that additional wall outlets are needed. Follow these procedures when using power strips:

- Use only NRTL (Nationally Recognized Testing Laboratory) tested power strips, and be sure they are used only as intended by their NRTL listing.
- Select power strips that are properly rated for the application. For example, in a wet chemistry laboratory the power strip must be rated for corrosive and indoor wet locations.
- Read and understand the manufacturer's instructions and limitations on the power strip. For example, the on/off switch on the power strip may not be designed to interrupt the power of the devices plugged into the strip during normal applications.
- Do not overload the circuit. Review the capacity of the circuit and the power requirements of all of the items plugged into it. This includes not only the items plugged into the power strip but also other devices plugged into wall outlets along the same circuit.

Section 6: Use of Clamp Lighting

Clamp lighting refers to lamps that can be attached to objects (such as desks, benchtops, or equipment) using a clamp connected to the lamp assembly. These devices are commonly available at many home and office product retailers. Clamp lighting poses special hazards in the laboratory due to the generation of heat and the potential for the equipment to accidentally fall. Follow these procedures when using clamp lighting:

- Use only NRTL (Nationally Recognized Testing Laboratory) tested clamp lights, and ensure they are used only as intended by their NRTL listing.
- Use clamp lights that are properly rated for the application. Many clamp lights can not be used in a wet environment.
- Clamp lights may not be attached to any surface within 6 feet of a water source (e.g. sinks, emergency showers, water tanks). Clamp lights may not be attached to any surface directly above a water source at any distance.
- Prevent lights from contacting combustible materials (such as paper goods). Move combustible materials at least three feet away from the lamp reflector surface. Move any combustible materials that could potentially fall onto the reflector surface to another location.
- Do not wrap excess cord around the lamp. The reflector surface gets very hot and may damage the cord jacket.
- Inspect cords daily prior to use for cracks, wear, or exposed conductor wires. Discard lamps with damaged cords.

Section 7: Ground Fault Circuit Interrupters

Ground Fault Circuit Interrupters, or GFCIs, are designed to protect the end user from electrical shock. GFCIs are not required on all circuits in laboratories. Best management practices in laboratory safety call for all outlets within 6-feet of a water source (such as a sink) or in a wet environment to have GFCI protection. All maintenance requests and renovation designs must include a provision for GFCI

protection under these circumstances. Older buildings may be "grandfathered" and exempt from this requirement.

If a laboratory currently has outlets with GFCI protection, they should be tested at least once per month. Laboratory personnel are responsible for testing the GFCI. To test the receptacle GFCI, first plug a lamp into the outlet and turn it on. Next, press the "TEST" button on the GFCI. Under properly functioning conditions, the GFCI's "RESET" button should pop out and the light will turn off. Press the "RESET" button to restore power to the outlet.

- If the "RESET" button pops out but the light does not go out, the GFCI has been improperly wired. Contact Maintenance Control to correct the wiring errors.
- If the "RESET" button does not pop out, the GFCI is defective and should be replaced.

Section 8: Changes to Building Electrical Services

Changes to electrical services in the laboratory may only be performed by an electrician that is properly licensed in the State of New Hampshire. Adding or modifying building circuitry or wiring are examples of a change to the electrical service. Changes are requested by contacting the Facilities Support Center as appropriate.

Section 9: Damaged or Defective Equipment

Any of the following circumstances requires that the user immediately take the equipment out of service:

- Experiencing shocks, even mild shocks, when the equipment is touched;
- Abnormal heat generation; and
- Arcing, sparking, or smoking from the equipment.

Laboratory personnel must tag the equipment, "Do Not Use" and should arrange for equipment repair either through the equipment manufacturer or through the Facilities Support Center as appropriate.

Section 10: Special Considerations

Please follow these guidelines when working with electrical equipment or devices:

- Laboratory personnel frequently construct equipment such as lighting fixtures or housings for use in specialty applications. All electrical equipment constructed by UNH employees or students must be inspected prior to use by a New Hampshire licensed electrician or qualified electrical engineer. All electrical equipment must be constructed in accordance with the requirements of the current National Electric Code.
- If flammables are used, electrical equipment with motors must be rated for Class I Division II environments. This requirement is waived if the motor is permanently housed in a fume hood or fitted with special local exhaust

ventilations designed to prevent flammable concentrations of gases or vapors from reaching the motor.

- Refrigerators used to store flammable chemicals must be certified by the manufacturer.
- Variac is a brand name for a type of variable voltage transformer. These transformers are used to control the temperature of heating mantles and sometimes for the rate of a stirring motor, or heating a high vacuum line. Some older models of Variacs will keep whatever is plugged into them electrically live even though the Variac is switched off! Touching this device and ground at the same time could complete a circuit with your body and lead to electrocution.
- Install ground fault circuit interrupter (GFCI) outlets within 6 feet of a water source.
- Electrophoresis devices should be evaluated for electrical safety concerns.

Chapter 14 – Individual Health and Safety Plan

Section 1: Individual Laboratory Safety Plan

Section 1: Individual Laboratory Safety Plan

The **Laboratory Safety Plan** provides a general outline of laboratory policies and procedures. This plan should be adapted by each faculty member to meet the specific needs in his/her laboratory by adding safety and health policies and procedures specified by the faculty member and the department. The following is suggested list of information to be included:

- Hazardous Materials being used in the laboratory
- Required Training
- Medical Monitoring
- Registrations/Notifications/Permits
- List of Laboratory Personnel
- Special Emergency Procedures
- Individual Laboratory Procedures
- Departmental Policies and Procedures

A sample form has been included which can be further developed to meet the needs of individual laboratories (see **Appendix U** for an example).

Appendix A – Glossary

ACGIH (**A**merican **C**onference of **G**overnmental **I**ndustrial **H**ygienists)	Organization of professionals in government agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits for chemical substances and physical agents (see TLV and BEI).
Acute	An adverse effect on the human body with symptoms of high severity coming quickly to a crisis.
Allergic Sensitization	A condition acquired through exposure to a particular substance. Additional exposure may cause a more severe reaction.
Aspiration	The removal of fluids or gases from a cavity by suction.
BEI (Biological Exposure Indices)	Levels of determinants in specimens from a healthy worker who has been exposed to chemicals. A reference value for biological monitoring.
BSC	Biological Safety Cabinet.
Bronchitis	The inflammation of one or more of the larger passages leading to the lungs.
Carcinogen	A substance that has been shown to cause malignant (cancerous) tumors.
Catalyst	A chemical which changes the rate of a chemical reaction between two other chemicals without affecting the chemical itself.
UNHCEMS™	Chemical and Environmental Management System.
Chronic	An adverse effect on the human body with symptoms, which develop slowly over a long period of time or which frequently recur.
Combustible	A chemical or agent with a flashpoint at or above 100ºF but below 200ºF.
Compressed Gas	Liquefied, pressurized gas typically stored in metal cylinders.
Conjunctivitis	The inflammation of the delicate membrane lining the eyelids and covering the eyeball.
Cornea	The transparent membrane that covers the anterior part of the eye.
Corrosive	A chemical that causes visible destruction of or irreversible alterations in, living tissue by chemical action at the site of contact.
CSC	Chemical Safety Committee.
Cyanosis	A bluish discoloration of the skin, especially on the face and fingers, indicating a lack of sufficient oxygen in the blood.
Dermatitis	An inflammation of the skin.
Deflagration	The propagation of a reaction zone at a velocity that is less than the speed of sound in the unreacted medium.

Detonation	Propagation of a reaction zone at a velocity that is at or above the speed of sound in the unreacted medium.
Explosive	A chemical or agent that causes a sudden, almost instantaneous release of pressure, gas and heat when subjected to sudden shock, pressure or high temperature.
Evaporation Rate	A measure of the length of time required for a given amount of a substance to evaporate, compared with time required for an equal amount of ether or butyl acetate to evaporate.
Eye Hazard	A chemical or agent that adversely affects the eye or visual acuity of the eye.
Flammable	A chemical or agent with a flashpoint below 100ºF.
Flammable Limits (Explosive Limits)	Lower Flammable (Explosive) Limit - The lowest concentration of a combustible or flammable gas or vapor in air that will produce a flash of fire. Mixtures below this concentration are too "lean" to burn. Upper Flammable (Explosive) Limit - The highest concentration of a combustible or flammable gas or vapor in air that will produce a flash of fire. Mixtures above this concentration are too "rich" to burn.
Flash Point	The lowest temperature at which a liquid will give off enough flammable vapor to ignite.
Hazardous Chemical	Any chemical whose presence or use is a physical or health hazard. Some examples include chemicals that are toxic, corrosive, flammable, highly reactive or explosive or emit ionizing radiation.
Health Hazard	Chemical, biological, radioactive or physical agents which may cause an adverse effect on the human body.
Hematopoetic Toxin	A chemical or agent that adversely affects blood function.
Hepatotoxin	A chemical or agent that adversely affects the liver.
IBC	Institutional Biosafety Committee (same as Biological Safety Committee).
IDLH (**I**mmediately **D**angerous to **L**ife and **H**ealth)	Immediately dangerous to life and health. The maximum concentration of a chemical from which one could escape within 30 minutes without any escape -impairing symptoms or irreversible health effects. (Note: carcinogenic effects are not considered in setting these values.)
Ingestion	The taking in of a substance through the mouth.
Inhibitor	A chemical which is added to another substance to prevent an unwanted chemical change from occurring.
Irritant	A chemical which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
LD_{50} (Lethal **D**ose **50)**	The single dose of a substance which causes the death of 50% of an animal population when exposed to the substance by any route other than inhalation. LD50 is usually expressed as milligrams or grams or material per kilogram of animal weight. (mg/kg or g/kg). The animal species and means of administering the dose (oral, intravenous, etc.) should also be stated.

Lavage	The washing or irrigation of an organ.
LEL, LFL (**L**ower **E**xplosive **L**imit, **L**ower **F**lammable **L**imit)	Refers to the lowest concentration of gas or vapor (% by volume in air) that burns or explodes if an ignition source is present at ambient temperatures.
LSO	Laboratory Safety Officer.
Lung Hazard	A chemical or agent that adversely affects lung tissue.
MSDS	Material Safety Data Sheet.
Mutagen	A substance that causes changes in the genetic material in cells. Some mutagens may also be carcinogens.
Narcosis	An unconscious state, normally caused by a drug.
Nephrotoxin	A chemical or agent that adversely affects the kidneys.
Neurotoxin	A chemical or agent that adversely affects the nervous system.
Organic Peroxide	A chemical or agent that contains the bivalent –O–O– structure and may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.
OSHA	**O**ccupational **S**afety and **H**ealth **A**dministration, United States Department of Labor.
Oxidizing Material	A chemical which gives off free oxygen in a chemical reaction. This includes chemicals such as peroxides, chlorates, perchlorates, nitrates and permanganates. These can react vigorously when stored in contact with reducing materials.
PEL (**P**ermissible **E**xposure **L**imit)	Established by OSHA this maybe expressed as a time-weighted average (TWA) limit or a ceiling exposure limit (CEL). OSHA PELs have the force of the law.
Polymerization	A chemical reaction in which two or more small molecules combine to form larger molecules.
Pulmonary Edema	An abnormal accumulation of fluid in the lungs.
Pyrophoric	Chemicals or agents that ignite spontaneously in air at a temperature of 130 ºF (54.4 ºC) or below.
Reactivity	A measure of the tendency of a substance to undergo chemical reaction with the release of energy.
Reducing Material	A chemical which absorbs oxygen or accepts electrons in a chemical reaction.
Reproductive Heath Hazard	A chemical, physical or biological agent that causes reproductive impairment in adults and/or developmental impairment or death in the embryo/fetus or child. Men and women of childbearing potential should take care to avoid exposure.
Reproductive Toxin	A chemical or agent that adversely affects reproductive functions.
RSC	Radiation Safety Committee.

RSO	Radiation Safety Officer.
Sensitizer	A chemical that causes those exposed to develop an allergic reaction after repeated exposure (See allergic sensitization above).
Skin Hazard	A chemical or agents that adversely affects the dermal layer of skin.
Solubility	A measure of the amount of the substance that will dissolve in a given amount of water or other solvent.
Spontaneous Heating	An increase in the internal temperature of substance due to a chemical or physical change without the application of external heat
Stability	A measure of the ability of a substance to be handled and stored without undergoing unwanted chemical changes.
Systemic	Affecting the body as a whole.
Teratogen	A substance which interferes with embryonic or fetal development. Women of child bearing potential should take care to avoid exposure.
Thermal Decomposition	Chemical breakdown of a material brought about by exposure to heat.
TLV (**T**hreshold **L**imit **V**alue)	The airborne concentration of a substance which represents conditions under which it is believed that nearly all workers may be repeatedly exposed day after day (for eight hours each day) without adverse effects.
TLV-C (**T**hreshold **L**imit **V**alue - **C**eiling)	The airborne concentration of a substance that should not be exceeded during any part of the working day.
Toxicity	The measure of the adverse effect exerted on the human body by a poisonous material.
Unstable Reactive	Chemicals or agents that vigorously polymerize, decompose, condense or become self-reactive under conditions of shock, pressure or temperature.
Vapor Density	Relates the density of the vapors from a substance to the density of air. Chemicals with a vapor density less than 1 will rise and those with a value greater than 1 will sink in air.
Vapor Pressure	The pressure a vapor exerts when it is in equilibrium with its liquid or solid form. Units are usually expressed in mm of Hg.
Volatile	Evaporates quickly.
Water Reactive	A chemical or agent that reacts with water to release a gas that is either flammable or presents a health hazard.

Appendix B – References

1. Fire Protection Guide on Hazardous Materials. National Fire Protection Association, Quincy, MA (latest edition).
2. Laboratory Safety: Principles and Practices. Fleming, D. O. et al. American Society for Microbiology. Washington, D.C. (latest edition)
3. Chemical Hazards of the Workplace. Proctor, N. and J. Hughes. J.B. Lippincott Co., Philadelphia, PA (latest edition).
4. Prudent Practices for Handling Hazardous Chemicals in Laboratories. National Research Council Committee on Hazardous Substances in the Laboratory. National Academy Press, Washington, D.C. (latest edition).
5. Dangerous Properties of Industrial Materials. Sax, N. Irving. Van Nostrand Reinhold, New York, NY (latest edition).
6. CRC Handbook of Laboratory Safety, Steere, N. ed. CRC Press, Inc., Boca Raton, FLA (latest edition).
7. The Merck Index. Windholz, M., ed. Merck and Co. Inc., Rahway, N.J. (latest edition).

OEHS has the following publications available at no charge:

1. Material Safety Data Sheets.
2. Laboratory Safety Plan.
3. Hazardous Waste Management Plan.
4. Radiation Protection Program.
5. Safety in Academic Chemistry Laboratories, American Chemical Society (latest edition).
6. Biosafety in Microbiological and Biomedical Laboratories, U.S. Department of Health and Human Services (available at http://www.cdc.gov/OD/ohs/biosfty/bmbl5/bmbl5toc.htm).

Appendix C – Laboratory Accident Form

This form must be completed in the event of a laboratory accident, fire, explosion, chemical, biological, or radiological spill, regardless of whether an injury occurred. It may be completed by the person affected by the incident, a witness, or the laboratory supervisor or manager. This form should take less than 5 minutes to complete.

In the event of an injury or illness, the Workers' Compensation forms must also be completed if you are an employee of the University (e.g., paid by the University System of New Hampshire).

Please complete the following questions relating to the incident:

1. On what date did the incident occur? _____

2. At what time, approximately, did the incident occur? _____

3. In which building did the incident occur? _____

4. In which room did this incident occur? _____

5. What is/are the name(s) of the injured person(s)? _____

6. Was medical treatment sought? Yes No

7. If yes, where: _____

8. How would you describe the nature of the incident? _____

_____

_____

9. Who is the manager or supervisor of the laboratory? _____

10. Was the person listed in Question #9 person notified of the incident? Yes No

11. Describe the events leading to the incident. Include a description of all pertinent details such as materials used, reactions, reaction setups, etc. _____

_____

_____

12. What personal protective equipment was being worn at the time of the incident? _____

_____

_____

13. What engineering controls were being used?_____

_____

_____

14. What specific laboratory safety references (e.g., MSDS, science textbooks) were consulted prior to work with the substances involved in the incident? _____

_____

_____

15. How did you respond to the incident? _____

_____

_____

16. What steps will be taken to prevent or minimize the chance of the incident from occurring in the future? _____

_____

_____

17. What is your name (the person completing this form)? _____

18. What is your telephone number (where we may reach you to discuss this incident)? _____

_____

19. With which department are you affiliated? _____

_____

Appendix D – Biological Safety Survey

BIOLOGICAL SAFETY SURVEY

☐ **BSL-1** ☐ **BSL-2** ☐ **BSL-2/Polio** ☐ **BSL-3**

Inspector Information

Inspector: _____ **Inspection Date:** _____

Administrative Information

College: _____ **Department:** _____
Building: _____ **Lab Location(s):** _____

PC = Primary Contact SC = Secondary Contact

PC: _____ **SC:** _____
PC Office: _____ **SC Office:** _____
PC Telephone #: _____ **SC Telephone #:** _____
PC Emergency #: _____ **SC Emergency #:** _____
PC E-mail: _____ **SC E-mail:** _____

Laboratory Information

Type of Registration (if applicable): ☐ **Infectious Agent Registration** ☐ **rDNA** ☐ **BBP**
IBC Approval: ☐ **YES** ☐ **NO** **IACUC Approval:** ☐ **YES** ☐ **NO**
Agents: _____
_____
_____

Emergency Procedures

☐ **YES** ☐ **NO** ☐ **N/A** Occupants of the laboratory know the campus emergency number, 911?
☐ **YES** ☐ **NO** ☐ **N/A** There is a telephone w/ 911 sticker attached, in the laboratory?
☐ **YES** ☐ **NO** ☐ **N/A** Occupants know what to do in the event of a chemical or biological spill?
☐ **YES** ☐ **NO** ☐ **N/A** Occupants know what to do in the event of a fire or injury?
☐ **YES** ☐ **NO** ☐ **N/A** A biological spill kit is easily accessible? Location: _____?
☐ **YES** ☐ **NO** ☐ **N/A** The spill kit vesicle is non-breakable and contains: nitrile or latex gloves, disinfectant (i.e. bleach, Lysol™), paper towels, tongs and utility gloves.

Personal Protective Equipment (PPE)

☐ **YES** ☐ **NO** ☐ **N/A** PPE is easily accessible and worn when appropriate. Type of PPE present:

☐ **Lab coats or gowns**
☐ **Goggles with side and temple shields**
☐ **Safety glasses**
☐ **Face shield**
☐ **Disposable gloves**
☐ **Utility gloves**
☐ **Hearing protection**
☐ **Booties or shoe covers**
☐ **Respirators (List type)**
_____
_____
_____

☐ **YES** ☐ **NO** ☐ **N/A** Laboratory occupants do not wear open-toed shoes, sandals, flip-flops, clogs, etc.
☐ **YES** ☐ **NO** ☐ **N/A** Laboratory occupants wear gowns/lab coats when large areas of skin are exposed (i.e. when lab occupants wear shorts, skirts, etc.).

Laboratory Facilities

☐ **YES** ☐ **NO** ☐ **N/A** The door to the laboratory is posted with a **Hazard and Emergency Information Sign** with the NFPA 704 diamond, emergency telephone numbers and entry requirements posted.

☐ **YES** ☐ **NO** ☐ **N/A** A hand-washing sink is available, supplied with soap and paper towels.

☐ **YES** ☐ **NO** ☐ **N/A** If lab windows can be opened, they have been fitted with screens.
Comments: _____

☐ **YES** ☐ **NO** ☐ **N/A** Sightings of insects, rodents and other pests are reported to Facilities Support Center (862-1437)?
Comments: _____

☐ **YES** ☐ **NO** ☐ **N/A** Vacuum line filter protection is in place. If yes, please indicate the type:
☐ **Central (Main)** ☐ **Local pump** ☐ **Sink**

☐ **YES** ☐ **NO** ☐ **N/A** Animals are housed within the facility.
If yes, how long: _____

☐ **YES** ☐ **NO** ☐ **N/A** A fermentor is used to grow bacteria. If yes, please indicate the following:

Building	***Room #***	***Make***	***Model***	***Serial #***	***Volume Use (L)***

BSL-2

☐ **YES** ☐ **NO** ☐ **N/A** The **Hazard and Emergency Information Sign** displays the ***biohazard*** symbol, the name of the agent(s) in use and any entry requirements.

☐ **YES** ☐ **NO** ☐ **N/A** Equipment in which potentially infectious materials are present is labeled with the ***biohazard*** symbol.

☐ **YES** ☐ **NO** ☐ **N/A** Laboratory biological safety cabinets are present in room. If yes, please indicate the following:

Building	***Room #***	***Make***	***Model***	***Serial #***	***Date Certified***

☐ **YES** ☐ **NO** ☐ **N/A** Airflow vents in the biosafety cabinet are not blocked (with supplies, equipment, etc.).

☐ **YES** ☐ **NO** ☐ **N/A** Biological safety cabinets or other safety devices are used to contain aerosols.

☐ **YES** ☐ **NO** ☐ **N/A** Procedures to minimize aerosol formation are developed and followed.

University Policies

☐ **YES** ☐ **NO** ☐ **N/A** The **UNH Laboratory Safety Plan** is easily accessible.

☐ **YES** ☐ **NO** ☐ **N/A** University rules regarding the use and disposal of ***sharps*** (e.g. hypodermic needles, scalpel blades, Pasteur pipettes) has been reviewed (see **Appendix F**) by laboratory personnel.

Bloodborne Pathogen Usage

☐ **YES** ☐ **NO** ☐ **N/A** The **UNH Bloodborne Pathogen Program** has been reviewed and is easily accessible.

☐ **YES** ☐ **NO** ☐ **N/A** All laboratory personnel have been offered the Hepatitis B vaccine.

Laboratory Work Practices

☐ **YES** ☐ **NO** ☐ **N/A** Staff is forbidden to eat, drink, store food, apply make-up (including lip balm), insert contact lenses, etc., in the laboratory.

☐ **YES** ☐ **NO** ☐ **N/A** Mechanical pipetting devices are in use; mouth pipetting is forbidden.

☐ **YES** ☐ **NO** ☐ **N/A** Hands are washed at the end of experiments, when gloves are removed and prior to leaving the lab.

☐ **YES** ☐ **NO** ☐ **N/A** Work surfaces are wiped down with disinfectant at the end of work and after spills. The following disinfectants are used and their dilutions are:

_____ **ratio** ____ **:** ____ or **percent** ____ **%**

_____ **ratio** ____ **:** ____ or **percent** ____ **%**

_____ **ratio** ____ **:** ____ or **percent** ____ **%**

☐ **YES** ☐ **NO** ☐ **N/A** Workstations, closets, etc. are clean, neat and orderly?

☐ **YES** ☐ **NO** ☐ **N/A** Biological waste containers are covered when not actively adding waste?

☐ **YES** ☐ **NO** ☐ **N/A** Aisles and corridors are free of obstruction and tripping hazards?

☐ **YES** ☐ **NO** ☐ **N/A** All doors from the laboratory are unobstructed, in case of emergency?

☐ **YES** ☐ **NO** ☐ **N/A** Combustible storage (boxes, paper) is kept to a minimum and is not stored within 24" of the ceiling in non-sprinkled buildings or within 18" of the sprinkler head in sprinkled buildings?

☐ **YES** ☐ **NO** ☐ **N/A** The trash containers are noncombustible and emptied regularly?

☐ **YES** ☐ **NO** ☐ **N/A** Interoffice doors to offices/other labs are closed when not in use?

BSL-2

☐ **YES** ☐ **NO** ☐ **N/A** Doors to the lab are kept closed when BSL-2 experiments are in progress.

☐ **YES** ☐ **NO** ☐ **N/A** If a work surface cover is used it is discarded when dirtied or contaminated.

☐ **YES** ☐ **NO** ☐ **N/A** If potentially infectious materials are centrifuged, safety containment cups or sealed rotors with O-rings are available.

☐ **YES** ☐ **NO** ☐ **N/A** Reusable glassware is decontaminated prior to machine washing.

Select Agent and Poliovirus Usage

☐ **YES** ☐ **NO** ☐ **N/A** CDC Select Agents or polioviruses are being used. If yes, please indicate the following:

- ☐ The project is registered with the Institutional Biosafety Committee (IBC).
- ☐ The facility has been registered with the CDC.
- ☐ Individuals in the lab are aware of restrictions on transferring, receiving, storage and use of select agents/polioviruses.
- ☐ The select agent/poliovirus is secured under lock and key when not in use.
- ☐ All doors to the laboratory are kept locked when not in use.
- ☐ Access is restricted to allow only authorized individuals.
- ☐ Records of stocks/strains are maintained.
- ☐ Stocks of unused select agents/polioviruses that are no longer used are destroyed.
- ☐ An annual inventory of select agents/polioviruses is completed and maintained.

Safety Equipment

☐ **YES** ☐ **NO** ☐ **N/A** A drench shower is unobstructed (at least 3 square feet)?

☐ **YES** ☐ **NO** ☐ **N/A** All persons in the laboratory are aware of the location of the drench shower?

☐ **YES** ☐ **NO** ☐ **N/A** A fire extinguisher is available in the laboratory? Location: _____?

☐ **YES** ☐ **NO** ☐ **N/A** All fire extinguishers have been inspected?

☐ **YES** ☐ **NO** ☐ **N/A** An eyewash station is easily accessible? (Bottled eyewashes are not recommended)

☐ **YES** ☐ **NO** ☐ **N/A** The eyewash station is "flushed" weekly (recommended for at least 3 minutes)?

☐ **YES** ☐ **NO** ☐ **N/A** A first-aid kit is available in the laboratory?

☐ **YES** ☐ **NO** ☐ **N/A** The kit contains clean, sterile bandages, pads, bandaids, tape, ice packs?

Chemical Safety

☐ **YES** ☐ **NO** ☐ **N/A** All hazardous/odiferous/toxic chemicals are used in an approved fume hood?
☐ **YES** ☐ **NO** ☐ **N/A** Flammable liquid storage is kept to an absolute minimum?
☐ **YES** ☐ **NO** ☐ **N/A** Flammable liquids are stored in approved safety cans, flammable storage cabinets or flammable storage refrigerators?
☐ **YES** ☐ **NO** ☐ **N/A** All chemicals have been registered through UNHCEMS™ (http://www.cems.sr.unh.edu)?
☐ **YES** ☐ **NO** ☐ **N/A** Chemicals are inventoried regularly to reduce unwanted/outdated material?
☐ **YES** ☐ **NO** ☐ **N/A** Chemicals are not placed or stored on the floor?
☐ **YES** ☐ **NO** ☐ **N/A** All chemicals and containers are properly labeled?
☐ **YES** ☐ **NO** ☐ **N/A** Particularly hazardous chemicals are used in an approved fume hood (see **Appendix T**)?

Fume Hoods & Exhaust Systems

☐ **YES** ☐ **NO** ☐ **N/A** The fume hood is being used at a proper sash height?
☐ **YES** ☐ **NO** ☐ **N/A** Airflow in hood is not blocked or restricted?
☐ **YES** ☐ **NO** ☐ **N/A** Occupants contact Facilities Maintenance (862-1437) if they suspect a fume hood problem?
☐ **YES** ☐ **NO** ☐ **N/A** Laboratory has window-mounted air-conditioning units? How many: _____?

Chemical Waste

☐ **YES** ☐ **NO** ☐ **N/A** Chemical waste is located in a properly identified area (satellite accumulation area)?
☐ **YES** ☐ **NO** ☐ **N/A** Each chemical waste container identifies each and every chemical within?
☐ **YES** ☐ **NO** ☐ **N/A** All chemical waste containers are capped when not in use?
☐ **YES** ☐ **NO** ☐ **N/A** The **UNH Hazardous Waste Management Plan** has been reviewed and is easily accessible.
☐ **YES** ☐ **NO** ☐ **N/A** If chemical waste is generated, all personnel have taken the online Hazardous Waste Training?

Biological Waste Handling & Disposal

☐ **YES** ☐ **NO** ☐ **N/A** An autoclave is present?
☐ **YES** ☐ **NO** ☐ **N/A** The autoclave is used to decontaminate:
☐ **Waste** ☐ **Media** ☐ **Other:** _____
If yes, please indicate:
Length of cycle? _____ **minutes.**
Temperature? _____ **Fahrenheit** or _____ **Celsius.**
Pressure? _____ **mm Hg** or _____ **lbs/in²**.
Location of the autoclave?
Building: _____ **Room #:** _____
Who is responsible for overseeing the operation of the autoclave:
Name: _____ **Title:** _____
☐ **YES** ☐ **NO** ☐ **N/A** The autoclave is validated by spore testing. If yes, please indicate:
Spore strains used for decontamination: _____?
Last spore test date: _____?
Frequency of testing: _____?
☐ **YES** ☐ **NO** ☐ **N/A** Liquid biohazardous waste is chemically decontaminated or autoclaved prior to sink disposal?
☐ **YES** ☐ **NO** ☐ **N/A** Sharps are collected in puncture resistant sharps containers, labeled with a ***biohazard*** symbol?
☐ **YES** ☐ **NO** ☐ **N/A** Sharps containers are closed when not in use and replaced before ¾ full or protruding.
☐ **YES** ☐ **NO** ☐ **N/A** Non-autoclaved biohazardous waste is collected within durable, leakproof containers, labeled with a ***biohazard*** symbol, lined with **two** red ***biohazard*** bags.
☐ **YES** ☐ **NO** ☐ **N/A** Biological burn boxes are sealed when they are ¾ full or when they reach 55 pounds, whichever occurs first.
☐ **YES** ☐ **NO** ☐ **N/A** Biological burn boxes are labeled with the building, room number and name of the originating lab.

Appendix E – Laboratory Safety Survey

Doors

☐ YES	☐ NO	☐ N/A	**1.**	The door Caution Sign is up to date?
☐ YES	☐ NO	☐ N/A	2.	Appropriate pictograms are present (i.e. Biosafety, Radioactive Materials, X-rays etc.)?
☐ YES	☐ NO	☐ N/A	3.	Vision panel in door is free from obstructions?

Gas Cylinders

☐ YES	☐ NO	☐ N/A	4.	All gas cylinders are properly capped or regulated?
☐ YES	☐ NO	☐ N/A	5.	All gas cylinders are properly secured or fastened in an upright position?
☐ YES	☐ NO	☐ N/A	6.	All flammable gas cylinders are located at least 3 feet away from doors?
☐ YES	☐ NO	☐ N/A	7.	All gas cylinders are located at least 30 inches away from electrical panels?
☐ YES	☐ NO	☐ N/A	8.	Particularly Hazardous Gases are used in approved fume hood or gas cabinet?
☐ YES	☐ NO	☐ N/A	9.	Gas cylinders are transported on appropriate carts with straps/chains?
☐ YES	☐ NO	☐ N/A	10.	Flammable gas cylinders are not stored next to oxidizing gases?

Refrigerators

☐ YES	☐ NO	☐ N/A	11.	Flammable liquids are not stored in household refrigerators?
☐ YES	☐ NO	☐ N/A	12.	Food and beverages are not stored in the refrigerator?
☐ YES	☐ NO	☐ N/A	13.	All chemicals and containers are properly labeled?
☐ YES	☐ NO	☐ N/A	14.	Refrigerators are cleaned and are regularly maintained?

Electrical Safety

☐ YES	☐ NO	☐ N/A	15.	Equipment is properly grounded?
☐ YES	☐ NO	☐ N/A	16.	Room occupants test GFCI devices monthly?
☐ YES	☐ NO	☐ N/A	17.	Extension cords are not run through doors, windows, walls, ceilings?
☐ YES	☐ NO	☐ N/A	18.	All electrical cords are in good condition, without defect?
☐ YES	☐ NO	☐ N/A	19.	Electrical cords do not present a tripping hazard?
☐ YES	☐ NO	☐ N/A	20.	Clamp lighting is more than 6' away from water sources?
☐ YES	☐ NO	☐ N/A	21.	Clamp lighting is more than 3' away from combustible materials?
☐ YES	☐ NO	☐ N/A	22.	Electrical disconnects clearly marked?

General Building Safety

☐ YES	☐ NO	☐ N/A	23.	Aisles, corridors and exits are free of obstruction and tripping hazards?
☐ YES	☐ NO	☐ N/A	24.	Written lockout-tagout (LOTO) procedures are in place?
☐ YES	☐ NO	☐ N/A	25.	Overhead cranes and hoists labeled on each side with manufacturer load rating?
☐ YES	☐ NO	☐ N/A	26.	Combustible storage (boxes, paper) is kept to a minimum and is not stored within 24" of the ceiling in non-sprinkled buildings or within 18" of the sprinkler head in sprinkled buildings?
☐ YES	☐ NO	☐ N/A	27.	Fire doors are kept closed and unobstructed?
☐ YES	☐ NO	☐ N/A	28.	The ceiling is intact (i.e., ceiling tiles in place, etc.)?
☐ YES	☐ NO	☐ N/A	29.	Penetrations in firewalls are sealed with appropriate firestop material?

University Policies

☐ YES	☐ NO	☐ N/A	30.	The UNH Laboratory Safety Plan is easily accessible.
☐ YES	☐ NO	☐ N/A	31.	University rules regarding the use and disposal of sharps (e.g. hypodermic needles, scalpel blades, Pasteur pipettes) has been reviewed (see **Appendix F**) by laboratory personnel.

Emergency Procedures

☐ YES ☐ NO ☐ N/A 32. The spill kit contains: absorbent, safety glasses, gloves. Location: _____

☐ YES ☐ NO ☐ N/A 33. Occupants of the room know the campus emergency number, 911?

☐ YES ☐ NO ☐ N/A 34. There is a telephone w/ 911 sticker attached, in the room?

☐ YES ☐ NO ☐ N/A 35. A biological spill kit is easily accessible? Location: _____

☐ YES ☐ NO ☐ N/A 36. The spill kit is non-breakable and contains: nitrile or latex gloves, disinfectant (i.e. bleach, Lysol™), paper towels, tongs and utility gloves.

☐ YES ☐ NO ☐ N/A 37. Occupants know evacuation route and areas of assembly in case of emergency?

Personal Protective Equipment (PPE)

☐ YES ☐ NO ☐ N/A 38. PPE is easily accessible and worn when appropriate. Type of PPE present:

☐ **Lab coats or gowns**	☐ **Disposable gloves**	☐ **Respirators (List type)**
☐ **Goggles**	☐ **Utility gloves**	_____
☐ **Safety glasses**	☐ **Hearing protection**	_____
☐ **Face shield**	☐ **Booties or shoe covers**	_____

☐ YES ☐ NO ☐ N/A 39. Occupants do not wear open-toed shoes, sandals, flip-flops, clogs, etc.

☐ YES ☐ NO ☐ N/A 40. Occupants wear gowns/lab coats when large areas of skin are exposed (i.e. when lab occupants wear shorts, skirts, etc.).

☐ YES ☐ NO ☐ N/A 41. All occupants wear appropriate gloves?

☐ YES ☐ NO ☐ N/A 42. All occupants wear the appropriate eye/face protection?

☐ YES ☐ NO ☐ N/A 43. Loose clothing and long hair do not come in contact with equipment?

☐ YES ☐ NO ☐ N/A 44. Visitors are required to wear personal protective equipment?

☐ YES ☐ NO ☐ N/A 45. Occupants have been certified to wear a respirator?

Facilities

☐ YES ☐ NO ☐ N/A 46. A hand washing sink is available, supplied with soap and paper towels.

☐ YES ☐ NO ☐ N/A 47. The room does not show signs of mold contamination.

☐ YES ☐ NO ☐ N/A 48. If lab windows can be opened, they have been fitted with screens.

☐ YES ☐ NO ☐ N/A 49. Belts, pulleys, and other exposed moving equipment parts are guarded to prevent injury?
Comments: _____

☐ YES ☐ NO ☐ N/A 50. Vacuum line filter protection is in place. If yes, please indicate the type:
☐ **Central (Main)** ☐ **Local pump** ☐ **Sink**

☐ YES ☐ NO ☐ N/A 51. Animals are not housed within the room.

☐ YES ☐ NO ☐ N/A 52. A fermentor is used to grow bacteria. If yes, please indicate the following:

Make	***Model***	***Serial #***	***Volume Use (L)***
_____	_____	_____	_____

Work Practices

☐ YES ☐ NO ☐ N/A 53. Staff does not eat, drink, store food, apply make-up (including lip balm), insert contact lenses, etc., in the room.

☐ YES ☐ NO ☐ N/A 54. Mechanical pipetting devices are in use; mouth pipetting does not occur.

☐ YES ☐ NO ☐ N/A 55. Hands are washed at the end of experiments and gloves are removed prior to leaving the room.

☐ YES ☐ NO ☐ N/A 56. Workstations, closets, etc. are clean, neat and orderly?

☐ YES ☐ NO ☐ N/A 57. The trash containers are noncombustible and emptied regularly?

Safety Equipment

☐ YES ☐ NO ☐ N/A 58. A drench shower is unobstructed (at least 3 square feet)?
☐ YES ☐ NO ☐ N/A 59. All persons in the room are aware of the location of the drench shower?
☐ YES ☐ NO ☐ N/A 60. A fire extinguisher is available in the room?
☐ YES ☐ NO ☐ N/A 61. All fire extinguishers have been inspected?
☐ YES ☐ NO ☐ N/A 62. All fire extinguishers are unobstructed?
Comments: _____
☐ YES ☐ NO ☐ N/A 63. An eyewash station is easily accessible? (Bottled eyewashes are not recommended)
☐ YES ☐ NO ☐ N/A 64. Bottled eyewash solution is not expired?
☐ YES ☐ NO ☐ N/A 65. The eyewash station is "flushed" weekly (recommended for at least 3 minutes)?
☐ YES ☐ NO ☐ N/A 66. A first-aid kit is available in the room?
☐ YES ☐ NO ☐ N/A 67. Occupants know the location of the first aid kit?
☐ YES ☐ NO ☐ N/A 68. The kit contains clean, sterile bandages, pads, bandaids, tape?

Chemical Safety

☐ YES ☐ NO ☐ N/A 69. Occupants know how/where to access MSDSs?
☐ YES ☐ NO ☐ N/A 70. All hazardous/odiferous/toxic chemicals are used in an approved fume hood?
☐ YES ☐ NO ☐ N/A 71. Incompatible chemicals segregated (i.e. no water reactives under the sink, etc.).
☐ YES ☐ NO ☐ N/A 72. Flammable liquids are stored in approved safety cans, flammable storage cabinets or flammable storage refrigerators?
☐ YES ☐ NO ☐ N/A 73. Ether and other highly flammable liquids are stored away from sources of heat, direct sunlight and ignition?
☐ YES ☐ NO ☐ N/A 74. All chemicals have been registered through UNHCEMS™ (http://www.cems.sr.unh.edu)?
☐ YES ☐ NO ☐ N/A 75. All chemical containers are capped and sealed except when actively adding or removing materials?
☐ YES ☐ NO ☐ N/A 76. Chemicals are not placed or stored on the floor?
☐ YES ☐ NO ☐ N/A 77. All chemicals and containers are properly labeled?
☐ YES ☐ NO ☐ N/A 78. Particularly hazardous chemicals are used in an approved fume hood (see **Appendix T**)?

Fume Hoods & Exhaust Systems

☐ YES ☐ NO ☐ N/A 79. The fume hood is being used at a proper sash height?
☐ YES ☐ NO ☐ N/A 80. Airflow in hood is not blocked or restricted?
☐ YES ☐ NO ☐ N/A 81. Occupants contact Facilities (862-1437) if they suspect a fume hood problem?
☐ YES ☐ NO ☐ N/A 82. Room has window-mounted air-conditioning units? How many: _____?

Chemical Waste

☐ YES ☐ NO ☐ N/A 83. Chemical waste is located within the area of generation?
☐ YES ☐ NO ☐ N/A 84. Each hazardous waste container has a completed EHS hazardous waste label including proper identification of contents?
☐ YES ☐ NO ☐ N/A 85. Chemical waste containers are in secondary containment?
☐ YES ☐ NO ☐ N/A 86. All chemical waste containers are capped when not in use?
☐ YES ☐ NO ☐ N/A 87. Room occupants know how to access the UNH Hazardous Waste Management Plan.
☐ YES ☐ NO ☐ N/A 88. If chemical waste is generated, all personnel have taken the online Hazardous Waste Training?

BIOLOGICAL SAFETY

☐ **BSL-1** ☐ **BSL-2**

BSL-2 Laboratory Facilities

☐ **YES** ☐ **NO** ☐ **N/A** 89. The door Caution sign displays the biohazard symbol, the name of the agent(s) in use and any entry requirements.

☐ **YES** ☐ **NO** ☐ **N/A** 90. Equipment in which potentially infectious materials are used or stored is labeled with the biohazard symbol.

☐ **YES** ☐ **NO** ☐ **N/A** 91. Biological safety cabinets are present in room. If yes, please indicate the following:

Make	***Model***	***Serial #***	***Date Certified***

☐ **YES** ☐ **NO** ☐ **N/A** 92. Airflow vents in the biosafety cabinet are not blocked (with supplies, equipment, etc.).

☐ **YES** ☐ **NO** ☐ **N/A** 93. Biological safety cabinets or other safety devices are used to contain aerosols.

☐ **YES** ☐ **NO** ☐ **N/A** 94. Procedures to minimize aerosol formation are developed and followed.

Biological Waste Handling & Disposal

☐ **YES** ☐ **NO** ☐ **N/A** 95. An autoclave is present?

☐ **YES** ☐ **NO** ☐ **N/A** 96. The autoclave is validated by spore testing?

☐ **YES** ☐ **NO** ☐ **N/A** 97. Autoclave log available?

☐ **YES** ☐ **NO** ☐ **N/A** 98. Liquid biohazardous waste is chemically decontaminated or autoclaved prior to sink disposal?

☐ **YES** ☐ **NO** ☐ **N/A** 99. Sharps are collected in puncture resistant sharps containers, labeled with a biohazard symbol?

☐ **YES** ☐ **NO** ☐ **N/A** 100. Sharps containers are closed when not in use and replaced before ¾ full or protruding.

☐ **YES** ☐ **NO** ☐ **N/A** 101. Non-autoclaved biohazardous waste is collected within durable, leakproof containers, labeled with a biohazard symbol, lined with two red biohazard bags.

☐ **YES** ☐ **NO** ☐ **N/A** 102. Biological burn boxes are sealed when they are ¾ full or when they reach 55 pounds, whichever occurs first.

☐ **YES** ☐ **NO** ☐ **N/A** 103. Biological waste containers are covered when not actively adding waste?

☐ **YES** ☐ **NO** ☐ **N/A** 104. Biological burn boxes are labeled with the building, room number, and name of the originating lab.

☐ **YES** ☐ **NO** ☐ **N/A** 105. Infectious waste containers are not used for any other purpose.

BSL-2 Laboratory Work Practices

☐ **YES** ☐ **NO** ☐ **N/A** 106. Doors to the lab are kept closed when BSL-2 experiments are in progress.

☐ **YES** ☐ **NO** ☐ **N/A** 107. If a work surface cover is used it is discarded when dirtied or contaminated.

☐ **YES** ☐ **NO** ☐ **N/A** 108. If potentially infectious materials are centrifuged, safety containment cups or sealed rotors with O-rings are available.

☐ **YES** ☐ **NO** ☐ **N/A** 109. Reusable glassware is decontaminated prior to machine washing.

Bloodborne Pathogen Usage

☐ **YES** ☐ **NO** ☐ **N/A** 110. The UNH Bloodborne Pathogen Program has been reviewed and is easily accessible.

☐ **YES** ☐ **NO** ☐ **N/A** 111. All personnel have been offered the Hepatitis B vaccine.

Additional Comments:

Auditor Information

Auditor(s): _____ **Audit Date:** _____

Appendix F – Sharps

Sharps can be defined as any device having corners, edges or projections with the potential of cutting or piercing the skin. This pertains to both regulated sharps contaminated with biohazardous waste and sharps that pose a safety hazard to custodial staff and other personnel.

The following items are examples of regulated sharps and must be disposed in sharps containers and managed as medical waste, whether or not they are contaminated with biohazardous waste:

- Needles, including those with syringes, vacutainers and attached tubing.
- Scalpels.
- Razors.
- Surgical saw blades.
- Glass pipettes.
- Glass slides.

When disposing of glassware contaminated with biohazardous waste, it must be placed into a biological burn box. If the broken glassware is contaminated with infectious material, it must be placed into a sharps container prior to placement into the burn box. Examples include:

- Glass bottles.
- Test tubes.
- Flasks.

SHARPS CLASSIFICATIONS

There are three classes of sharps waste produced at UNH. This information complies with OSHA's Bloodborne Pathogen Standard (29 CFR 1910.1030) and federal, state and local waste disposal guidelines. The disposal procedures for these classes are as follows:

Class 1: Non-chemically contaminated broken glass and Non-biologically contaminated broken glass

This class consists of any type of broken glass that has been rinsed of any chemical contamination, including:

- Solvent bottles.
- Chemical bottles.
- Test tubes.
- Broken flasks.

Procedure for disposal:

1. Place waste in a sturdy, leakproof, puncture-resistant broken glass box.
2. Securely close the box and label it with the building, room number and principal investigator.
3. Laboratory personnel should place the box directly into a dumpster.

Class 2: Chemically contaminated broken glass

This class consists of any broken glass that is contaminated with a "P" listed waste. Contact the Hazardous Waste Coordinator at 862-3526 to determine if a chemical is on the "P" list. Glass contaminated with non-listed waste can be placed in a broken glass box. This includes:

- TLC plates.
- Flasks with irremovable residues.

Procedure for disposal:

1. Place waste in a puncture proof container that can be capped and sealed.
2. Label with a completed UNH Hazardous Waste label.
3. Call the Hazardous Waste Coordinator at 862-3526 to schedule a pickup.

Class 3: Biologically contaminated sharps

This class consists of:

- All biologically contaminated sharps from BSL-1, BSL-2 or BSL-3 laboratories.
- All syringes and needles, whether they are biologically contaminated or not.

Procedure for removal:

1. Place waste in Sharps containers for removal by Environmental Health and Safety. Sharps containers must be leakproof, puncture-resistant and labeled with the biohazard symbol or the word "Biohazard."
2. Place the sharps container in an infectious agent burn box.
3. Secure the box, seal it with tape and label it with the building, room number and principal investigator.
4. Call the Hazardous Waste coordinator at 862-3526 to schedule a pickup.

If your lab is not a BSL-1, BSL-2 or BSL-3 lab and generates syringes and needles only:

- Place waste in a puncture-resistant container (such as a red sharps container).
- Place the container in an infectious agent burn box and call the Hazardous Waste Coordinator at 862-3526 for pickup.

The following are general guidelines for all sharps containers in the laboratory:

- Never overfill sharps containers.
- Close the lid on sharps containers when they are ¾ full.
- Never re-use sharps containers.

Appendix G – Autoclaves and Indicators

Steam Sterilization

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 utilizing saturated steam under a pressure of approximately 15 pounds per square inch (psi) to achieve a chamber temperature of at least 121ºC (250ºF) for a minimum of 15 minutes. The time is measured after the temperature of the material being sterilized reaches 121ºC (250ºF).

Physical controls such as pressure gauges and thermometers are widely used but are considered secondary methods of sterilization. The use of appropriate biological indicators at locations throughout the autoclave is considered the best indicator of sterilization. The biological indicator most widely used for wet heat sterilization is a *Bacillus stearothermophilus* spore suspension or strip. If sterilization is associated with patient diagnosis, the biological indicator and associated documentation is required by law.

Chemical Indicators

1. Chemical Color Change Indicators

   Chemical indicators for steam autoclaving change colors after being exposed for a few minutes to normal autoclave operating temperatures of 121ºC (250ºF). Hence, chemical indicators can give a quick visual reference for heat penetration inside the hood. Chemical indicators should be positioned near the center of each load and toward the bottom front of the autoclave.

   Caution: Most chemical indicators can only be used to verify that your autoclave has reached normal operating temperatures for decontamination; they have no time factor. Chemical indicators alone are not designed to prove that organisms are actually killed during a decontamination cycle.

2. Tape Indicators

   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." These markings only appear when the tape has been exposed for a few minutes to normal autoclave decontamination temperatures.

   Caution: Tape indicators can only be used to verify that your autoclave has reached normal operating temperatures for decontamination; they have no time factor. Tape indicators alone are not designed to prove that organisms are actually killed during a decontamination cycle.

Biological Indicators

Biological indicators are designed to demonstrate that an autoclave is capable of killing microorganisms. Only *Bacillus stearothermophilus* spores can be used to monitor the effectiveness of steam autoclaves.

Typical biological indicator systems consist of a vial with spore strips or a small glass ampoule of growth medium with spores and indicator dye. Refer to manufacturer's instructions for usage. The biological is removed from a load after it has been autoclaved. Then the biological indicator is incubated at 56ºC (132.8ºF) for up to three days. A control vial, which is not autoclaved, should remain clear without evidence of turbidity (no growth). If the autoclaved biological indicator is turbid (cloudy, indicating growth) the autoclave did not function properly. Notify your supervisor if this occurs.

Autoclave Procedures

When using a steam autoclave, consider the following:

1. Never autoclave FLAMMABLE, REACTIVE, CORROSIVE, TOXIC or RADIOACTIVE MATERIALS.
2. Always wear safety glasses, goggles or face shield, lab coat or apron, and heat-protective non-asbestos gloves when opening door or removing item(s) from autoclave.
3. Open door slowly; beware of a rush of steam.
4. 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.
5. Do not mix loads which require different exposure times and exhaust.
6. Materials that will melt (e.g., plastic lab wear) and block chamber exhaust drain should be placed in a shallow stainless steel autoclave pan.

Autoclave Packaging and Treatment

Materials contaminated with infectious materials must be collected in the appropriate containers and sterilized or disinfected before disposal. Specific requirements for handling, sterilizing, and disposing infectious waste must be followed.

A. Liquids containing Biohazardous Agents

- Collect liquids in leak-proof containers such as flasks or bottles.
- Liquid waste containers designed to withstand autoclaving temperatures must be used when steam sterilization is utilized. To allow pressure equalization, they should not be sealed.

B. Solids Containing Biohazardous Agents

- Non-sharp, solid laboratory waste (e.g., empty plastic cell culture flasks, Petri dishes, empty plastic tubes, gloves, wrappers, absorbent tissues) which may be, or is known to be, contaminated with infectious material must be collected in autoclavable bags. If this

waste is not autoclaved immediately, it must be stored in autoclavable bags displaying the biohazard-warning symbol.

- Autoclavable bags should be used for solid, non-sharp, infectious waste only and disposed of appropriately. They should not be used for the collection of other solid hazardous or non-hazardous waste that may require other treatment or disposal methods.
- For laboratories generating large volumes of agar gel in disposable Petri dishes and tubes requiring sterilization, such waste should be collected in an autoclavable plastic pail in the laboratory. Autoclavable bags filled with plastic ware containing agar gel tend to leak fluids during and after the sterilization process. The pail will contain the liquids released by the agar gel.

C. Sterilization and Disinfection

- Inactivate the biological agents by employing steam sterilization procedures. Autoclaving (steam sterilization) is the preferred (and generally regarded as the most reliable) method of sterilizing biological waste. Depending on the volume of waste to be sterilized, it may be necessary to extend the duration of exposure to high temperature steam under pressure.
- Steam sterilization is generally not recommended for laboratory waste contaminated with or containing a combination of viable biological agents and significant amounts of hazardous chemical or radioactive materials.
- Containers of liquid waste must be placed in an autoclavable tray or pan of sufficient capacity to contain all liquid in the event of vessel failure or breakage inside the autoclave chamber. Use extreme caution when handling autoclaved liquids since they are hot and may boil over.
- Autoclavable bags of solid waste should be gently closed (but not sealed airtight) to allow steam penetration before they are placed into the autoclave chamber.
- After autoclaving and cooling, these bags of autoclaved waste must be placed into double-lined black plastic garbage bags (available at most stores and through many vendors). The international biohazard symbol must be removed from all autoclaved materials.
- When full, close the black bag by gathering the opening and applying a twist tie, string, tape, or tying a knot.

Storage and Disposal

Following steam sterilization innocuous liquids may be disposed of via the laboratory drainage system. Contact the Office of Environmental Health and Safety at 862-3526 with any questions about disposing waste down the drain. **NOTE:** Do not pour melted agar into sink or floor drains. Allow it to cool and solidify for disposal as a solid waste in black garbage bags.

Autoclaved Waste Labeling

No specific labeling is required. Make sure the there are no biohazard stickers on the treated infectious waste and associated bags. Wording such as "infectious," "pathogenic," "biohazardous," etc. must be removed prior to placing the black garbage bags into an approved dumpster. Contact OEHS at 862-4041 for more information.

Appendix H – Biosafety Level Summary Table

Biosafety Level	Risk Group	Agents	Practices	Safety Equipment (Primary Barriers)	Facilities (Secondary Barriers)
1	Individual Risk: LOW Community Risk: LOW	Not known to consistently cause disease in healthy adults	Standard Microbiological Practices	None required Primary containment provided by adherence to standard lab practices during open bench operations.	Open bench top sink required
2	Individual Risk: MODERATE Community Risk: LOW	Associated with human disease, hazard = percutaneous injury, ingestion, mucous membrane exposure	***BSL-1 practice plus:*** • Limited access • Biohazard warning signs • "Sharps" precautions • Biosafety manual defining any needed waste decontamination or medical surveillance policies	***Primary barriers*** = Class I or II BSCs or other physical containment devices used for all manipulations of agents that cause splashes or aerosols of infectious materials; PPEs: laboratory coats; gloves; face protection as needed.	***BSL-1 plus:*** Autoclave available
3	Individual Risk: HIGH Community Risk: MODERATE	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	***Primary barriers*** = Class I or II BCSs or other physical containment devices used for all open manipulations of agents; PPEs: protective lab clothing; gloves; respiratory protection as needed.	***BSL-2 plus:*** • Physical separation from access corridors • Self-closing, double-door access • Exhausted air not recirculated • Negative airflow into laboratory
4	Individual Risk: HIGH Community Risk: HIGH	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	***Primary barriers*** = 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 decon systems • Other requirements outlined in the text

Appendix I – Chemical Inactivation of Certain Toxins

Complete Inactivation of Different Toxins with a 30 Minute Exposure Time to Varying Concentrations of Sodium Hypochlorite (NaOCl) + Sodium Hydroxide (NaOH)				
Toxin	**2.5% NaOCl + 0.25 N NaOH**	**2.5% NaOCl**	**1.0% NaOCl**	**0.1% NaOCl**
T-2 Mycotoxin	Yes	No	No	No
Brevetoxin	Yes	Yes	No	No
Microcystin	Yes	Yes	Yes	No
Tetrodotoxin	Yes	Yes	Yes	No
Saxitoxin	Yes	Yes	Yes	Yes
Palytoxin	Yes	Yes	Yes	Yes
Ricin	Yes	Yes	Yes	Yes
Botulinum Toxin	Yes	Yes	Yes	Yes
Staphylococcal Enterotoxin B	Yes (?)	Yes (?)	Yes (?)	Yes (?)

Wannemacher, R.W. 1989. Procedures for Inactivation and Safety Containment of Toxins. In: Proceedings of the Symposium on Agents of Biological Origin, U.S. Army Research, Development and Engineering Center, Aberdeen Proving Ground, MD, pp. 115-122.

Appendix J – Autoclave Inactivation of Certain Toxins

Complete Inactivation of Different Toxins By Autoclaving or 10 Minute Exposure to Varying Temperatures of Dry Heat					
Toxin	**Autoclaving**	**Dry Heat (ºF)**			
		200	**500**	**1000**	**1500**
T-2 Mycotoxin	No	No	No	No	Yes
Brevetoxin	No	No	No	No	Yes
Microcystin	No	No	Yes	Yes	Yes
Tetrodotoxin	No	No	Yes	Yes	Yes
Saxitoxin	No	No	Yes	Yes	Yes
Palytoxin	No	No	Yes	Yes	Yes
Ricin	Yes	No	Yes	Yes	Yes
Botulinum Toxin	Yes	Yes	Yes	Yes	Yes
Staphylococcal Enterotoxin B	Yes (?)	Yes (?)	Yes (?)	Yes (?)	Yes (?)

Wannemacher, R.W. 1989. Procedures for Inactivation and Safety Containment of Toxins. In: Proceedings of the Symposium on Agents of Biological Origin, U.S. Army Research, Development and Engineering Center, Aberdeen Proving Ground, MD, pp. 115-122.

Appendix K – Summary of Practical Disinfectants

Disinfectants		Practical Requirements					Inactivates				Important Characteristics											
			Contact Time (Minutes)																			
Type	Category	Use Dilution	Lipovirus	Broad Spectrum	Temperature, °C	Relative Humidity, %	Vegetative Bacteria	Lipoviruses	Nonlipid Viruses	Bacterial Spores	Effective Shelf Life > 1 week[γ]	Corrosive	Flammable	Explosion Potential	Residue	Inactivated by Organic Matter	Compatible for Optics[ϕ]	Compatible for Electronics	Skin Irritant	Eye Irritant	Respiratory Irritant	Toxic[ψ]
Liquid	Quaternary Ammonium Compounds	0.1 - 2.0%	10	NE			+	+			+					+	+		+	+		+
	Phenolic compounds	1.0 - 5.0%	10	NE			+	+	[δ]		+	+			+				+	+		+
	Chlorine compounds	500 ppm[ω]	10	30			+	+	+	+		+			+	+			+	+	+	+
	Iodophor compounds	25 - 1600 ppm[ω]	10	30			+	+	+	+	+	+			+	+			+	+		+
	Ethyl alcohol	70 - 85%	10	NE			+	+	[δ]		+		+							+		+
	Isopropyl alcohol	70 - 85%	10	NE			+	+	[δ]		+		+							+		+
	Formaldehyde	0.2 - 8.0%	10	30			+	+	+	+	+				+				+	+		+
	Glutaraldehyde	2%	10	30			+	+	+	+	+				+		+		+	+		+
Gas	Ethylene oxide	8 - 23 g/ft³	60	60	37	30	+	+	+	+	NA		+[τ]	+[τ]			+	+	+	+	+	+
	Paraformaldehyde	0.3 g/ft³	60	60	>23	>60	+	+	+	+	NA		+[π]	+[π]			+	+	+	+	+	+

γ Protected from light and air. **ϕ** Usually compatible. **ψ** By skin or mouth or both. **ω** Available halogen. **δ** Variable results. **τ** Not flammable or explosive in 90% CO2 or fluorinated hydrocarbon, the usual form. **π** At concentrations of 7 to 73% by volume in air, solid-exposure to open flame. **NE** Not Effective.

SOURCE: Department of Health and Human Services, National Institutes of Health, "Laboratory Safety Monograph," 1979.

Appendix L – Effectiveness of Certain Disinfectants

Disinfectant	Concentration (active ingredients)	Contact Time (min)	Effective Against*					
			Vegetative Bacteria (B)	Fungi (F)	Lipophilic Viruses (LV)	Tubercle Bacillus (TB)	Hydrophilic Viruses (HV)	Spores (S)
Quaternary Ammonium	0.1 - 0.2%	10 - 30	++	++	++	-	-	-
Phenolic compounds	0.2 - 3.0%	10 - 30	++	++	++	++	+	-
Chlorine Compounds ** (available chlorine)	0.01 - 5.0%	10 - 30	++	++	++	++	++	+
Iodophor Compounds)	0.5%	10 - 30	++	++	++	++	+	-
Alcohol (ethyl or isopropyl)	70 - 85%	10 - 30	++	++	++	-	+	-
Formaldehyde	4 - 8%	10 - 30	++	++	++	++	++	+
Glutaraldehyde	2%	10 - 600	++	++	++	++	++	++

* B = Vegetative bacteria; F = fungi and asexual spores but not necessarily chlamydospores or sexual spores; LV = lipophilic viruses; TB = tubercle bacillus; HV = hydrophilic viruses; S = spores; + = positive response; ++ = very positive response; - = negative response.

** Household bleach contains approximately 5% available chlorine.

*** References: "Decontamination, Sterilization, Disinfection and Antisepsis in the Microbiology Laboratory," in Laboratory Safety: Principles and Practices and "Sterilization, Disinfection and Antisepsis in the Hospital," in Manual of Clinical Microbiology.

Appendix M – Chemical Disinfectants

Disinfectant	Final Concentration**	Effective on:	Ineffective on:	Comments
Phenolics: *e.g.* Lysol™*	1/20	Bacteria, most viruses, TB, HIV	Spores, polio, Coxsackie viruses.	Relatively insensitive to high protein concentrations. Corrosive.
Chlorine Bleaches: *e.g.* Chlorox™*	1:10	Bacteria, some spores, viruses, TB†, HIV	Some spores	Prepare once a week. It takes ~20 minutes to disinfect. Corrosive.
Iodophors: *e.g.* Wescodyne™*	1:100	Bacteria, most viruses, TB	Spores	A surface disinfectant. Iodine is insoluble so it's not good in solutions. Corrosive.
Alcohols: e.g. ethanol, isopropanol	70%	Bacteria, most viruses	Spores, TB	At 100% alcohols are a preservative!! Flammable.

* The use of brand names does not imply a recommendation.
** Concentration of named brands.
† Use 1/5 dilution

Appendix N – Summary of Spill Responses

Where	Hazard Type	First Step	Garb	Clean up
In Cabinet	BSL-1, BSL-2	Leave cabinet fan on.	Goggles, Heavy Gloves, Lab Coat	Spray 1/20 Lysol™, let sit 20 min. Mop up with paper towels
Out of Cabinet	BSL-1	Surround spill with absorbent and disinfectant	Goggles, Heavy Gloves, Lab Coat	Cover spill with disinfectant from outside ring. Mop up with paper towels
	BSL-2	Surround spill with absorbent and disinfectant	Face mask - Dust mask or HEPA are best. Goggles, Heavy Gloves, Lab Coat	Cover spill with disinfectant from outside ring. Mop up with paper towels
	BSL-3	**EVACUATE AREA, CALL FOR HELP**	***Serious Accident:*** **Notify supervisor and call 862-4041 immediately.**	
	Blood	Surround spill with absorbent and disinfectant	Goggles, Heavy Gloves, Lab Coat	Cover spill with disinfectant from outside of spill inward. Mop up.
	Radioactive	BLOCK OFF AREA, Call Radiation Safety Officer	Varies with radionuclide.	Inactivate biological spill first, then deal with radioactivity.

Appendix O – Incompatible Chemicals

The following list is to be used only as a guide. Consult the MSDS for specific incompatibilities.

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, 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, powdered 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, fulminic 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, glycerin, ethylene glycol, ethylacetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium, lithium)
Tellurides	Reducing agents
Zinc powder	Sulfur
Source: *Safety in Academic Chemistry Laboratories*, published by The American Chemical Society.	

Incompatible Chemicals and Wastes

Many chemicals, when mixed with other chemicals or materials, can produce effects which are harmful to human health and the environment, such as (1) heat or pressure, (2) fire or explosion, (3) violent reaction, (4) toxic dusts, mists, fumes, or gases, or (5) flammable fumes or gases.

Below are examples of potentially incompatible chemicals or materials, along with the harmful consequences, which result from mixing materials in one group with materials in another group. The list is intended as a guide to indicate the need for special precautions when managing these potentially incompatible materials or components. This list is not intended to be exhaustive.

Group 1 **Potential consequences:** Heat generation; violent reaction	
A	**B**
Acetylene sludge Alkaline caustic liquids Alkaline cleaner Alkaline corrosive liquids Alkaline corrosive battery fluid Caustic water Lime sludge and other corrosive alkalis Lime wastewater Lime and water Spent caustic	Acid sludge Acid and water Battery acid Chemical cleaners Electrolyte, acid Etching acid liquid or solvent Mixed acid Pickling liquor and other corrosive acids Spent acid Sulfuric acid

Group 2 **Potential consequences:** Fire or explosion; generation of flammable hydrogen gas.	
A	**B**
Aluminum Beryllium Calcium Lithium Magnesium Potassium Sodium Zinc powder Other reactive metals and metal hydrides	Any chemical or waste listed in **Group 1**

Group 3 **Potential consequences:** Fire, explosion, or heat generation; generation of flammable or toxic gases.	
A	**B**
Alcohols Water	Calcium Lithium Metal hydrides Potassium SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3 Other water-reactive waste Concentrated chemicals or wastes listed in **Group 1**

Group 4 **Potential consequences:** Fire, explosion, or violent reaction.	
A	**B**
Alcohols Aldehydes Halogenated hydrocarbons Nitrated hydrocarbons Unsaturated hydrocarbons Other reactive organic compounds and solvents	Concentrated chemicals or wastes listed in **Group 1**. Any chemical or waste listed in **Group 2-A.**

Group 5 **Potential consequences:** Generation of toxic hydrogen cyanide or hydrogen sulfide gas.	
A	**B**
Cyanide and sulfide solutions	Any chemical or waste listed in **Group 1-B**

Group 6 **Potential consequences:** Fire, explosion, or violent reaction.	
A	**B**
Chlorates Chlorine Chlorites Chromic acid Hyphochlorites Nitrates Nitric acid, fuming Perchlorates Permanganates Peroxides Other strong oxidizers	Acetic acid and other organic acids Concentrated mineral acids Other flammable and combustible chemicals/wastes Any chemical or waste listed in **Group 2-A** Any chemical or waste listed in **Group 4-A**

Source: "Law, Regulations, and Guidelines for Handling of Hazardous Waste." California Department of Health, February 1975.

Appendix P – High Energy Oxidizers

Here is a list of known high energy oxidizers. This list is not exhaustive.

Ammonium perchlorate (NH_4ClO_4)
Ammonium permanganate (NH_4MnO_4)
Barium peroxide (BaO_2)
Bromine (Br_2)
Calcium chlorate ($Ca[ClO_3]_2 2H_2O$)
Calcium hypochlorite ($Ca[ClO]_2$)
Chlorine trifluoride (ClF_3)
Chromium anhydride or chromic acid (CrO_3)
Dibenzoyl peroxide ($[C_6H_5CO]_2O_2$)
Fluorine (F_2)
Hydrogen peroxide (H_2O_2)
Magnesium perchlorate ($Mg[ClO_4]_2$)
Nitric acid (HNO_3)
Nitrogen peroxide (in equilibrium with nitrogen dioxide) N_2O_4; NO_2
Nitrogen trioxide (N_2O_3)
Perchloric acid ($HClO_4$)
Potassium bromate ($KBrO_3$)
Potassium chlorate ($KClO_3$)
Potassium perchlorate ($KClO_4$)
Potassium peroxide (K_2O_3)
Propyl nitrate (normal) (CH_3 $[CH_2]_2$ NO_3)
Sodium chlorate ($NaClO_3$)
Sodium chlorate ($NaClO_2$)
Sodium perchlorate ($NaC1O_4$)
Sodium peroxide (Na_2O_2)

Appendix Q – Common Organic Peroxides

	TYPICAL NFPA 704 RATING		
Organic Peroxide*	HEALTH	FLAMMABILITY	INSTABILITY
t-Amyl hydroperoxide	3	3	2
t-Amyl peroxyacetate	2	3	2
t-Amyl peroxybenzoate	2	3	2
t-Amyl peroxy-2-ethylhexanoate	0	3	2
t-Amyl peroxyneodecanoate	1	3	2
t-Amyl peroxypivalate	1	3	2
t-Butyl cumyl peroxide	2	2	2
n-Butyl-4,4-di(*t*-butyl peroxy) valerate	2	3	2
t-Butyl hydroperoxide	3	3	3
t-Butyl monoperoxymaleate	2	3	3
t-Butyl peroxyacetate	1	3	3
t-Butyl peroxybenzoate	1	3	3
t-Butyl peroxy-2-ethylhexanoate	1	3	3
t-Butylperoxy-2-ethylhexyl carbonate	1	3	2
t-Butyl peroxyisobutyrate	2	3	3
t-Butylperoxy isopropyl carbonate	1	3	3
t-Butyl peroxyneodecanoate	2	3	2
t-Butyl peroxypivalate	2	3	3
Cumyl hydroperoxide	3	2	2
Cumyl peroxyneodecanoate	1	3	2
Cumyl peroxyneoheptanoate	2	3	2
Diacetyl peroxide	2	3	3
1,1-Di(*t*-amylperoxy) cyclohexane	2	3	2
Dibenzoyl peroxide	1	3	4
Dibenzoyl peroxide (paste)	1	2	2
Dibenzoyl peroxide (slurry)	1	2	2
Dibenzoyl peroxide (powder)	1	0	0
Di (4-*t*-butylcyclohexyl) peroxydicarbonate	1	3	2
Di-*t*-butyl peroxide	1	3	2
2,2-Di(*t*-butylperoxy) butane	1	3	3
1,1-Di(*t*-butylperoxy) cyclohexane	1	3	3
Di-*sec*-butyl peroxydicarbonate	1	3	3
Di(2-*t*-butylperoxy-iso-propyl) benzene	1	2	2
Di(butylperoxy) phthalate	2	2	2
1,1-Di(*t*-butylperoxy)- 3,3,5-trimethyl-cyclohexane	2	3	3
Dicetyl peroxydicarbonate	1	2	2
Dicumyl peroxide	2	2	2
Didecanoyl peroxide	1	3	2
Di-2,4-dichlorobenzoyl peroxide	1	2	2
Di(2-ethylhexyl) peroxydicarbonate	1	3	3
Diisopropyl peroxydicarbonate	2	3	4
Di-*n*-propyl peroxydicarbonate	2	3	4
Dilauroyl peroxide	1	2	2
2,5-Dimethyl-2,5-di(benzoylperoxy)hexane	2	3	3
2,5-Dimethyl-2,5-di(*t*-butylperoxy) hexane	2	3	2
2,5-Dimethyl-2,5-di(2-ethylhexanoylperoxy) hexane	1	1	1
2,5-Dimethyl-2,5-dihydro-peroxyhexane	2	3	3
Ethyl-3,3-di(*t*-amylperoxy) butyrate	1	3	2
p-Menthyl hydroperoxide	3	2	2
Methyl ethyl ketone peroxide	3	2	2
Methyl ethyl ketone peroxide and Cyclohexanone peroxide mixture	3	2	2
2,4-Pentanedione peroxide	2	1	1
Peroxyacetic acid, Type E, stabilized	3	2	3

* List is not exhaustive. Source: NFPA 432.

Appendix R – Threshold Limit Values and Flammability of Some Commonly Used Gases

Substance	ACGIH Ceiling Level (C) or TLV-TWA*	Flammability
Acetylene [C_2H_2]		High, Explosive
Ammonia [NH_3]	25	High
Arsine [AsH_3]	0.05	High, Explosive
Boron Trifluoride [BF_3]	(C) 1	Low
1,3 Butadiene [C_4H_6]	2	High
Carbon Dioxide [CO_2]	5000	Low
Carbon Disulfide [CS_2]	10	High
Carbon Monoxide [CO]	25	High
Chlorine [Cl_2*]	0.5	Low
Cyanogen [C_2H_2*]	10	High
Cyanogen Chloride [CNCl]	(C) 0.3	Low
Diazomethane [CH_2NO_2]	0.2	Explosive
Diborane [B_2H_6]	0.1	High
Ethylene [C_2H_4]		High
Ethylene Oxide [C_2H_4O]	1.0	High
Fluorine	1	Low
Formaldehyde [CH_2O]	(C) 0.3	High
Hydrogen [H_2]		High, Explosive
Hydrogen chloride (anhydrous) [HCl]	(C) 5.0	Low
Hydrogen Cyanide	(C) 4.7	High
Hydrogen Fluoride [HF]	(C)3.0	Low
Hydrogen Selenide [H_2Se]	0.05	High
Hydrogen Sulfide [H_2Se]	10	High
Methane [CH_4]		High
Methyl Acetylene [C_3H_4]	1000	High
Methyl Acetylene Propadiene Mixture [MAPP]	1000	High
Methyl Bromide [CH_3Br]	1	High
Methyl Chloride [CH_3Cl]	50	High
Methyl Mercaptan [CH_4S]	0.5	High
Nickel Carbonyl [$Ni(CO)_4$]	0.05	High
Nitric Oxide [NO]	25	Low
Nitrogen Dioxide [NO_2]	3	Low
Nitrogen Trifluride [NF_3]	10	Low
Oxygen Difluoride [OF_2]	(C) 0.05	Low
Ozone [O_3]	0.05 - 0.2 [γ]	Low
Phosgene [CCl_2O]	0.1	Low
Phosphine [PH_3]	0.3	High
Propane [C_3H_8]	2500	High, Explosive
Propylene [C_3H_6]		High
Silane (Silicon Tetrahydride) [SiH_4]	5	High
Stibine [SbH_3]	0.1	High
Sulfur Dioxide [SO_2]	2	Low
Sulfur Tetrafluoride [SF_4]	(C)0.1	Low
Trifluorobromomethane (Halon 1301) [$CBrF_3$]	1000	Low
Vinyl Chloride [C_2H_3Cl]	1	High

* parts per million.

[γ] Depending on type of work.

References:

CRC Handbook of Laboratory Safety 3rd Edition
2000 Threshold Limit Values and Biological Exposure Indices, ACGIH
1991 NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals
ACGIH TLV-TWA: Threshold limit value (see glossary)
ACGIH TLV-C: Ceiling value (see glossary)

Appendix S – Carcinogens

Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2005 (http://ntp.niehs.nih.gov/).

Known Carcinogens

Substances or groups of substances, occupational exposures associated with a technological process and medical treatments that are ***known to be carcinogenic****.

Aflatoxins	Estrogens, Steroidal
Alcoholic Beverage Consumption	Ethylene Oxide
4-Aminobiphenyl	Hepatitis B Virus
Analgesic Mixtures Containing Phenacetin	Hepatitis C Virus
Arsenic Compounds, Inorganic	Human Papillomas Viruses: Some Genital-Mucosal Types
Asbestos	Melphalan
Azathioprine	Methoxsalen with Ultraviolet A Therapy (PUVA)
Benzene	Mineral Oils (Untreated and Mildly Treated)
Benzidine	Mustard Gas
Beryllium and Beryllium Compounds	2-Naphthylamine
1,3-Butadiene	Neutrons
1,4-Butanediol Dimethanesulfonate (Myleran®)	Nickel Compounds
Cadmium and Cadmium Compounds	Radon
Chlorambucil	Silica, Crystalline (Respirable Size)
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (MeCCNU)	Smokeless Tobacco
	Solar Radiation
bis(Chloromethyl) Ether and Technical-Grade	Soots
Chloromethyl Methyl Ether	Strong Inorganic Acid Mists Containing Sulfuric Acid
Chromium Hexavalent Compounds	Sunlamps or Sunbeds, Exposure to
Coal Tar Pitches	Tamoxifen
Coal Tars	2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD); "Dioxin"
Coke Oven Emissions	Thiotepa
Cyclophosphamide	Thorium Dioxide
Cyclosporin A	Tobacco Smoking
Diethylstilbestrol	Vinyl Chloride
Dyes Metabolized to Benzidine	Ultraviolet Radiation, Broad Spectrum UV Radiation
Environmental Tobacco Smoke	Wood Dust
Erionite	X-Radiation and Gamma Radiation

* For the purpose of this list, "known carcinogens" are defined as agents with "sufficient evidence of carcinogenicity from studies in humans, which indicates a causal relationship between exposure to the agent, substance or mixture and human cancer.

Probable Carcinogens

Substances or groups of substances and medical treatments which may reasonably be anticipated to be carcinogens**.

Acetaldehyde	1,2-Dibromoethane (Ethylene Dibromide)
2-Acetylaminofluorene	2,3-Dibromo-1-propanol
Acrylamide	tris(2,3-Dibromopropyl) Phosphate
Acrylonitrile	1,4-Dichlorobenzene
Adriamycin® (Doxorubicin Hydrochloride)	3,3´-Dichlorobenzidine and 3,3´-Dichlorobenzidine
2-Aminoanthraquinone	Dihydrochloride
o-Aminoazotoluene	Dichlorodiphenyltrichloroethane (DDT)
1-Amino-2,4-dibromoanthraquinone	1,2-Dichloroethane (Ethylene Dichloride)
1-Amino-2-methylanthraquinone	Dichloromethane (Methylene Chloride)
2-Amino-3,4-dimethylimidazo[4,5-f]quinoline (MeIQ)	1,3-Dichloropropene (Technical Grade)
2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline (MeIQx)	Diepoxybutane
2-Amino-3-methylimidazo[4,5-f]quinoline (IQ)	Diesel Exhaust Particulates
2-Amino-1-methyl-6-phenylimidazo[4,5-b]pyridine (PhIP)	Diethyl Sulfate
Amitrole	Diglycidyl Resorcinol Ether
o-Anisidine Hydrochloride	3,3´-Dimethoxybenzidine
Azacitidine (5-Azacytidine®, 5-AzaC)	4-Dimethylaminoazobenzene
Benz[a]anthracene	3,3´-Dimethylbenzidine
Benzo[b]fluoranthene	Dimethylcarbamoyl Chloride
Benzo[j]fluoranthene	1,1-Dimethylhydrazine
Benzo[k]fluoranthene	Dimethyl Sulfate
Benzo[a]pyrene	Dimethylvinyl Chloride
Benzotrichloride	1,6-Dinitropyrene
Bromodichloromethane	1,8-Dinitropyrene
2,2-bis-(Bromoethyl)-1,3-propanediol (Technical Grade)	1,4-Dioxane
Butylated Hydroxyanisole (BHA)	Disperse Blue 1
Carbon Tetrachloride	Dyes Metabolized to 3,3´-Dimethoxybenzidine
Ceramic Fibers (Respirable Size)	Dyes Metabolized to 3,3´-Dimethylbenzidine
Chloramphenicol	Epichlorohydrin
Chlorendic Acid	Ethylene Thiourea
Chlorinated Paraffins ($C1_2$, 60% Chlorine)	di(2-Ethylhexyl) Phthalate
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea	Ethyl Methanesulfonate
bis(Chloroethyl) nitrosourea	Formaldehyde (Gas)
Chloroform	Furan
3-Chloro-2-methylpropene	Glass Wool (Respirable Size)
4-Chloro-o-phenylenediamine	Glycidol
Chloroprene	Hexachlorobenzene
p-Chloro-o-toluidine and p-Chloro-o-toluidine Hydrochloride	Hexachlorocyclohexane Isomers
Chlorozotocin	Hexachloroethane
C.I. Basic Red 9 Monohydrochloride	Hexamethylphosphoramide
Cisplatin	Hydrazine and Hydrazine Sulfate
Cobalt Sulfate	Hydrazobenzene
p-Cresidine	Indeno[1,2,3-cd]pyrene
Cupferron	Iron Dextran Complex
Dacarbazine	Isoprene
Danthron (1,8-Dihydroxyanthraquinone)	Kepone® (Chlordecone)
2,4-Diaminoanisole Sulfate	Lead and Lead Compounds
2,4-Diaminotoluene	Lindane and Other Hexachlorocyclohexane Isomers
Diazoaminobenzene	2-Methylaziridine (Propylenimine)
Dibenz[a,h]acridine	5-Methylchrysene
Dibenz[a,j]acridine	4,4´-Methylenebis (2-chloroaniline)
Dibenz[a,h]anthracene	4-4´-Methylenebis (N,N-dimethyl) benzenamine
7H-Dibenzo[c,g]carbazole	4,4´-Methylenedianiline and its Dihydrochloride Salt
Dibenzo[a,e]pyrene	Methyleugenol
Dibenzo[a,h]pyrene	Methyl Methanesulfonate
Dibenzo[a,i]pyrene	N-Methyl-N´-nitro-N-nitrosoguanidine
Dibenzo[a,l]pyrene	Metronidazole
1,2-Dibromo-3-chloropropane	Michler´s Ketone [4,4´-(Dimethylamino) benzophenone]

Mirex	Phenytoin
Naphthalene	Polybrominated Biphenyls (PBBs)
Nickel (Metallic)	Polychlorinated Biphenyls (PCBs)
Nitrilotriacetic Acid	Polycyclic Aromatic Hydrocarbons (PAHs)
o-Nitroanisole	Procarbazine Hydrochloride
Nitrobenzene	Progesterone
6-Nitrochrysene	1,3-Propane Sultone
Nitrofen (2,4-Dichlorophenyl-p-nitrophenyl ether)	β-Propiolactone
Nitrogen Mustard Hydrochloride	Propylene Oxide
Nitromethane	Propylthiouracil
2-Nitropropane	Reserpine
1-Nitropyrene	Safrole
4-Nitropyrene	Selenium Sulfide
N-Nitrosodi-n-butylamine	Streptozotocin
N-Nitrosodiethanolamine	Styrene-7,8-oxide
N-Nitrosodiethylamine	Sulfallate
N-Nitrosodimethylamine	Tetrachloroethylene (Perchloroethylene)
N-Nitrosodi-n-propylamine	Tetrafluoroethylene
N-Nitroso-N-ethylurea	Tetranitromethane
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone	Thioacetamide
N-Nitroso-N-methylurea	4,4´-Thiodianaline
N-Nitrosomethylvinylamine	Thiourea
N-Nitrosomorpholine	Toluene Diisocyanate
N-Nitrosonornicotine	o-Toluidine and o-Toluidine Hydrochloride
N-Nitrosopiperidine	Toxaphene
N-Nitrosopyrrolidine	Trichloroethylene
N-Nitrososarcosine	2,4,6-Trichlorophenol
Norethisterone	1,2,3-Trichloropropane
Ochratoxin A	Ultraviolet A Radiation
4,4´-Oxydianiline	Ultraviolet B Radiation
Oxymetholone	Ultraviolet C Radiation
Phenacetin	Urethane
Phenazopyridine Hydrochloride	Vinyl Bromide
Phenolphthalein	4-Vinyl-1-cyclohexene Diepoxide
Phenoxybenzamine Hydrochloride	Vinyl Flouride

** For the purpose of this report, substances "which may reasonable be anticipated to be carcinogens" are defined as those agents with:

- Limited evidence of carcinogenicity from studies in humans, which indicates that causal interpretation is credible, but that alternative explanations, such as chance, bias or confounding factors, could not adequately be excluded," or
- Sufficient evidence of carcinogenicity from studies in experimental animals, which indicates there is an increased incidence of malignant and/or a combination of malignant and benign tumors (1) in multiple species or at multiple tissue sites or (2) by multiple routes of exposure or (3) to an unusual degree with regard to incidence, site or type of tumor or age at onset or
- Less than sufficient evidence of carcinogenicity in humans or laboratory animals; however, the agent, substance or mixture belongs to a well-defined, structurally related class of substances whose members are listed in a previous Report on Carcinogens as either known to be a human carcinogen or reasonably anticipated to be a human carcinogen or there is convincing relevant information that the agent acts through mechanisms indicating it would likely cause cancer in humans.

Appendix T – Particularly Hazardous Chemicals

Chemical	Acutely Toxic	Peroxidizable	Reproductive Toxin	Select Carcinogen	Glove Selection[ψ]
Acetal		Yes			
Acetaldehyde			Yes		Silver Shield™, butyl rubber, 4H
2-Acetylaminofluorine				Yes	
Acrolein	Yes				Butyl rubber
Acrylamide				Yes	(30-70%) Butyl rubber, polyvinyl chloride, nitrile rubber
Acrylonitrile				Yes	Butyl rubber, Silver Shield™
Aflatoxin				Yes	
Aflatoxin B1				Yes	
Aflatoxin B2				Yes	
Aflatoxin G1				Yes	
Aflatoxin G2				Yes	
Aflatoxin M1				Yes	
4-Aminobiphenyl				Yes	
Arsenic			Yes	Yes	
Arsine	Yes				
Asbestos				Yes	
Azathioprine				Yes	
Barium Chromate				Yes	
Benzene			Yes	Yes	Polyvinyl alcohol, Silver Shield™, Viton™
Benzidine				Yes	
Butadiene		Yes			Viton™
1,4-Butanediol Dimethylsulfonate				Yes	
Cadmium			Yes		
Carbon Disulfide			Yes		Polyvinyl alcohol, Viton™, Silver Shield™
Chloramabucil				Yes	
Chlorine	Yes				Neoprene, butyl rubber, nitrile rubber, Viton™
Chlornaphazine				Yes	Butyl rubber, natural rubber, Silver Shield™
Chloromethyl Methyl Ether				Yes	
Chloroprene		Yes			Polyvinyl alcohol, Viton™
Chromium				Yes	
Cumene		Yes			Viton™
Cyclohexene		Yes			
Cyclopentene		Yes			
Cyclophosphamide				Yes	
Decalin		Yes			Viton™
Diacetylene		Yes			
Diazomethane	Yes				
Diborane	Yes				
1,2-Dibromo-3-Chloropropane			Yes	Yes	
3-3'-Dichlorobenzidine				Yes	
Dicyclopentadiene		Yes			Nitrile rubber
Diethylene Glycol Dimethyl Ether		Yes			Polyethylene, polyvinyl alcohol
Diethyl ether		Yes			Polyvinyl alcohol, Silver Shield™
Diethylnitrosamine				Yes	Butyl rubber, Silver Shield™
Diethylstilbestrol				Yes	
4-Dimethylaminoazobenzene				Yes	
Dimethylmercury §	Yes				Silver Shield™
Dimethyl Sulfate				Yes	Butyl rubber, Silver Shield™
Dioxane		Yes			Silver Shield™, butyl rubber

Chemical	Acutely Toxic	Peroxidizable	Reproductive Toxin	Select Carcinogen	Glove Selection[Ψ]
Divinyl Ether		Yes			
Ethylene Dibromide				Yes	Viton™, Silver Shield™
Ethylene Glycol Dimethyl Ether		Yes			Butyl rubber
Ethylene Glycol Monoethyl Ether		Yes	Yes		Butyl rubber, Silver Shield™
Ethylene Glycol Monomethyl Ether		Yes	Yes		Butyl rubber
Ethylene Oxide			Yes	Yes	Butyl rubber, Silver Shield™
Ethylenimine				Yes	Butyl rubber
Formaldehyde				Yes	Nitrile rubber, Viton™, Silver Shield™, butyl rubber
Furan		Yes			Butyl rubber *(limited protection - search for a better alternative)*
Hexamethylphosphoramide				Yes	Butyl rubber *(limited protection - search for a better alternative)*
Hydrazine				Yes	Butyl rubber, polyvinyl chloride, nitrile rubber, neoprene
Hydrogen Cyanide	Yes				Silver Shield™
Hydrogen Fluoride and Hydrofluoric Acid	Yes				Neoprene *(limited protection - search for a better alternative)*
Isopropyl Ether		Yes			
Lead			Yes		
Melphalan				Yes	
Mercury			Yes		Silver Shield™
Methyl Fluorosulfate	Yes				
Methyl Acetylene		Yes			
Methylcyclopentane		Yes			
4,4'-Methylenebis (2-chloroaniline)				Yes	
Methyl Isobutyl Ketone		Yes			Butyl rubber, polyvinyl alcohol
Mustard Gas				Yes	Butyl rubber, Silver Shield™
α-Naphthylamine				Yes	
Nickel Carbonyl	Yes			Yes	
4-Nitrobiphenyl				Yes	
Nitrogen Dioxide	Yes				
Osmium Tetroxide	Yes				
Ozone	Yes				Viton™
Phosgene	Yes				
Potassium		Yes			Rubber, neoprene
Potassium Cyanide	Yes				(<30% KCN) Polyethylene
β-Propiolactone				Yes	
Sodium Amide		Yes			
Sodium Azide	Yes				
Sodium Cyanide	Yes				(Solid NaCN only) Natural rubber, neoprene, nitrile rubber, polyvinyl chloride
Styrene		Yes			Viton, polyvinyl alcohol, ethyl vinyl laminate
Tetrafluoroethylene		Yes			Butyl rubber, neoprene, polyvinyl alcohol, Viton™
Tetrahydrofuran		Yes			Silver Shield™
Tetralin		Yes			Nitrile
Thorium Dioxide				Yes	Rubber
Toluene			Yes		Silver Shield™, Viton™, polyvinyl alcohol
Treosulfan				Yes	
Vinyl Actetate		Yes			Polyethylene, ethylene vinyl alcohol
Vinylacetylene		Yes			
Vinyl Chloride		Yes	Yes	Yes	Nitrile rubber, Viton™
Vinylidine Chloride		Yes			Polyvinyl alcohol
Vinylpyridine		Yes			
Xylene			Yes		Silver Shield™, polyvinyl alcohol, Viton™

[§] Dimethylmercury is not allowed at UNH.

[Ψ] Check with the chemical manufacturer to determine which glove is correct for the work you will be performing.

Appendix U – Individual Health and Safety Plan

Individual Laboratory Safety Plan			
(To be filled out by faculty member)			
Faculty Member:		***Department:***	
Building:		***Room:***	
Office Phone:		***Lab Phone:***	
Identification of Hazards: **[e.g. chemical, biological, ionizing or non-ionizing radiation, physical (be specific)].**			
Required Training: **Include appropriate training (e.g. Biological Safety and Sharps Training, Hazard Communication Training, Fire Extinguisher Training, Radiation Safety Training), departmental training and individual lab training.**			
Medical Monitoring: **(e.g. if working with human blood, hepatitis B immunization must be offered).**			
Registrations/Notifications/Permits: **e.g. Animal Use (IACUC), radiation (RSC, OEHS), biohazards (IBC, OEHS).**			
Special Emergency Procedures			
List of Laboratory Personnel:			
Signature:		**Date:**	

Appendix V – Biological Agents & Biosafety Levels

	TYPE						BIOLOGICAL SAFETY LEVEL			
Agent	**Bacterial**	**Fungal**	**Parasitic**	**Prion**	**Rickettsia**	**Virus**	**BSL-1**	**BSL-2**	**BSL-3**	**BSL-4**
Bacillus anthracis	X							X $^{\propto}$		
Bordetella pertussis	X							X $^{\propto}$		
Brucella (B. abortus, B. canis, B. melitensis, B. suis)	X							X $^{\beta}$	X $^{\chi}$	
Burkholderia mallei (Pseudomonas mallei)	X							X $^{\propto}$		
Burkholderia pseudomallei (Pseudomonas pseudomallei)	X							X $^{\propto}$		
Campylobacter (C. jejuni/C. coli, C. fetus subsp. *fetus)*	X							X		
Chlamydia psittaci, C. pneumoniae, C. trachomatis)	X							X $^{\propto}$		
Clostridium botulinum	X							X $^{\propto}$		
Clostridium tetani	X							X		
Corynebacterium diphtheriae	X							X		
Escherichia coli (Cytotoxin-producing (VTEC/SLT) organisms)	X							X		
Francisella tularensis	X							X $^{\chi}$		
Helicobacter pylori	X							X		
Leptospira interrogans – all serovars	X							X		
Listeria monocytogenes	X							X		
Legionella pneumophila; other Legionella-like agents	X							X $^{\propto}$		
Mycobacterium leprae	X							X		
Mycobacterium spp. other than *M. tuberculosis, M. bovis* or *M. leprae*	X							X		
Mycobacterium tuberculosis, M. bovis	X							X $^{\delta}$		
Neisseria gonorrhoeae	X							X $^{\propto}$		
Neisseria meningitidis	X							X $^{\propto}$		
Salmonella – all serotypes except *typhi*	X							X		
Salmonella typhi	X							X $^{\propto}$		
Shigella spp.	X							X		
Treponema pallidum	X							X		
Vibrionic enteritis (Vibrio cholerae, V. parahaemolyticus)	X							X		
Yersinia pestis	X							X $^{\propto}$		
Blastomyces dermatitidis		X						X		
Coccidioides immitis		X						X $^{\varepsilon}$		
Cryptococcus neoformans		X						X		
Histoplasma capsulatum		X						X $^{\delta}$		

$\propto$ = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with antibiotic resistant strains or (3) engaged in large scale production operations.

β = Clinical specimens only.

χ = ↑ BSL category by one for all manipulations of cultures of the pathogenic agent or experimental animal studies.

δ = ↑ BSL category by one if propagating or manipulating cultures or if utilizing nonhuman primates for animal studies.

ε = ↑ BSL category by one if propagating or manipulating sporulating cultures.

ϕ = ↑ BSL category by one if propagating or manipulating human or primate prions.

γ = ↑ BSL category by one if (1) inoculating, incubating or harvesting embryonic eggs or cell cultures, (2) conducting necropsy of infected animals or (3) manipulating infected tissue.

η = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with infected animals or tissue or (3) engaged in work with large quantities of virus.

	TYPE						BIOLOGICAL SAFETY LEVEL			
Agent	**Bacterial**	**Fungal**	**Parasitic**	**Prion**	**Rickettsia**	**Virus**	**BSL-1**	**BSL-2**	**BSL-3**	**BSL-4**
Sporothrix schenckii		X						X		
Pathogenic Members of the Genera Epidermophyton, Microsporum and Trichophyton		**X**						X		
Miscellaneous Molds		**X**						X		
Blood and Tissue Protozoal Parasites of Humans			X					X		
Intestinal Protozoal Parasites of Humans			X					X		
Trematode Parasites of Humans (*Schistosoma* spp. and *Fasciola* spp.)			X					X		
Cestode Parasites of Humans – *Echinococcus granulosus, Taenia solium (cysticercus cellulosae)* and *Hymenolepis nana*			X					X		
Nematode Parasites of Humans			X					X		
Bovine spongiform encephalopathy (BSE) prion				X				X$^{\phi}$		
Chronic wasting disease (CWD) prion				X				X$^{\phi}$		
Creutzfeldt-Jakob disease (CJD) prion				X				X$^{\phi}$		
Exotic ungulate encephalopathy (EUE) prion				X				X$^{\phi}$		
Feline spongiform encephalopathy (FSE) prion				X				X$^{\phi}$		
Gatal familial insomnia (FFI) prion				X				X$^{\phi}$		
Gerstmann-Straussler-Scheinker syndrome (GSS) prion				X				X$^{\phi}$		
Kuru prion				X				X$^{\phi}$		
Scrapie prion				X				X$^{\phi}$		
Transmissible mink encephalopathy (TME) prion				X				X$^{\phi}$		
Coxiella burnettii					X			X$^{\gamma}$		
Rickettsia prowazekii, Rickettsia typhi, (R. mooseri) orientia (Rickettsia) tsutsugamushi and Spotted Fever Group agents of human disease, *Rickettsia rickettsii, Rickettsia conorii, Rickettsia akari, Rickettsia australis, Rickettsia siberica and* Rickettsia japonicum					X			X$^{\gamma}$		
Hantaviruses						X		X$^{\eta}$	X$^{\eta}$	
Hendra and Hendra-like Viruses (includes virus formerly know as Equine Morbillivirus)						X			X$^{\eta}$	
Hepatitis A Virus, Hepatitis E Virus						X		X		
Hepatitis B Virus, Hepatitis C Virus (formerly known as nonA nonB Virus), Hepatitis D Virus						X		X$^{\gamma}$		
Herpesvirus simiae (Cercopithecine herpesvirus [CHV-1], B-virus)						X		X$^{\eta}$	X$^{\eta}$	

$\propto$ = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with antibiotic resistant strains or (3) engaged in large scale production operations.

β = Clinical specimens only.

χ = ↑ BSL category by one for all manipulations of cultures of the pathogenic agent or experimental animal studies.

δ = ↑ BSL category by one if propagating or manipulating cultures or if utilizing nonhuman primates for animal studies.

ε = ↑ BSL category by one if propagating or manipulating sporulating cultures.

ϕ = ↑ BSL category by one if propagating or manipulating human or primate prions.

γ = ↑ BSL category by one if (1) inoculating, incubating or harvesting embryonic eggs or cell cultures, (2) conducting necropsy of infected animals or (3) manipulating infected tissue.

η = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with infected animals or tissue or (3) engaged in work with large quantities of virus.

	TYPE						BIOLOGICAL SAFETY LEVEL			
Agent	**Bacterial**	**Fungal**	**Parasitic**	**Prion**	**Rickettsia**	**Virus**	**BSL-1**	**BSL-2**	**BSL-3**	**BSL-4**
Human Herpesviruses						X		X		
Influenza						X		X		
Lymphocytic Choriomeningitis Virus						X		X $^{\eta}$		
Poliovirus						X		X $^{\eta}$		
Poxviruses						X		X		
Rabies Virus						X		X $^{\eta}$		
Retroviruses, including Human and Simian Immunodeficiency Viruses (HIV and SIV)						X		X $^{\eta}$		
Transmissible Spongiform Encephalopathies (Creutzfeldt-Jakob, kuru and related agents)						X		X		
Vesicular Stomatitis Virus						X		X $^{\eta}$		

For information about arboviruses, please refer to the CDC/NIH guidance document titled, "Biosafety in Microbiological and Biomedical Laboratories," latest edition at http://www.cdc.gov/od/ohs/biosfty/bmbl4/bmbl4toc.htm***.***

$\propto$ = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with antibiotic resistant strains or (3) engaged in large scale production operations.

β = Clinical specimens only.

χ = ↑ BSL category by one for all manipulations of cultures of the pathogenic agent or experimental animal studies.

δ = ↑ BSL category by one if propagating or manipulating cultures or if utilizing nonhuman primates for animal studies.

ε = ↑ BSL category by one if propagating or manipulating sporulating cultures.

ϕ = ↑ BSL category by one if propagating or manipulating human or primate prions.

γ = ↑ BSL category by one if (1) inoculating, incubating or harvesting embryonic eggs or cell cultures, (2) conducting necropsy of infected animals or (3) manipulating infected tissue.

η = ↑ BSL category by one if (1) there is a potential to create aerosols, (2) working with infected animals or tissue or (3) engaged in work with large quantities of virus.

Appendix W – Biological Agents Exempt from the NIH Guidelines

- *Bacillus amyloliquefaciens*
- *Bacillus aterrimus*
- *Bacillus globigii*
- *Bacillus licheniformis*
- *Bacillus nato*
- *Bacillus niger*
- *Bacillus pumilus*
- *Bacillus subtilis*
- Genus *Citrobacter* – including *Levinea*
- Genus *Enterobacter*
- Genus *Erwinia*
- Genus *Escherichia*
- Genus *Klebsiella* – including *oxytoca*
- Genus *Salmonella* – including *Arizona*
- Genus *Shigella*
- One way transfer of *Streptococcus mutans* or *Streptococcus lactis* DNA into *Streptococcus sanguis*
- *Pseudomonas aeruginosa, Pseudomonas putida, Pseudomonas fluorescens and Pseudomonas mendocina*
- *Serratia marcescens*
- *Streptococcus faecalis*
- *Streptococcus mutans*
- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*
- *Streptococcus sanguis*
- *Streptomyces aureofaciens*
- *Streptomyces coelicolor*
- *Streptomyces cyaneus*
- *Streptomyces griseus*
- *Streptomyces rimosus*
- *Streptomyces venezuelae*
- *Yersinia enterocolitica*

Recombinant DNA molecules derived entirely from extrachromosomal elements of the organisms listed below (including shuttle vectors constructed from vectors), propagated and maintained in organisms listed below are exempt from the *NIH Guideline*s.

Fungal Agents

- *Bacillus amyloliquefaciens*
- *Bacillus amylosacchariticus*
- *Bacillus anthracis*
- *Bacillus aterrimus*
- *Bacillus brevis*
- *Bacillus cereus*
- *Bacillus globigii*
- *Bacillus licheniformis*
- *Bacillus megaterium*
- *Bacillus natto*
- *Bacillus niger*
- *Bacillus pumilus*
- *Bacillus sphaericus*
- *Bacillus stearothermophilis*
- *Bacillus subtilis*
- *Bacillus thuringiensis*
- *Clostridium acetobutylicum*
- *Lactobacillus casei*
- *Listeria grayi*
- *Listeria monocytogenes*
- *Listeria murrayi*
- *Pediococcus acidilactici*
- *Pediococcus damnosus*
- *Pediococcus pentosaceus*
- *Staphylcoccus carnosus*
- *Staphylococcus aureus*
- *Staphylococcus epidermidis*
- *Streptococcus agalactiae*
- *Streptococcus anginosus*
- *Streptococcus avium*
- *Streptococcus cremoris*
- *Streptococcus dorans*
- *Streptococcus equisimilis*
- *Streptococcus faecalis*
- *Streptococcus ferns*
- *Streptococcus ferus*
- *Streptococcus lactis*
- *Streptococcus mitior*
- *Streptococcus mutans*
- *Streptococcus pneumoniae*
- *Streptococcus pyogenes*
- *Streptococcus salivarious*
- *Streptococcus sanguis*
- *Streptococcus sobrinus*
- *Streptococcus thermophylus*

Source: NIH Guidelines for Research Involving Recombinant DNA Molecules.

Appendix X – Risk Groups and Associated Agents from the NIH Guidelines

Risk Group 2 (RG2) – Agents associated with human disease which is rarely serious and for which preventive or therapeutic interventions are *often* available (work should be performed at BSL-2).

Bacterial Agents – Including Chlamydia

- *Acinetobacter baumannii* (formerly *Acinetobacter calcoaceticus*)
- *Actinobacillus*
- *Actinomyces pyogenes* (formerly *Corynebacterium pyogenes*)
- *Aeromonas hydrophila*
- *Amycolata autotrophica*
- *Archanobacterium haemolyticum* (formerly *Corynebacterium haemolyticum*)
- *Arizona hinshawii* – all serotypes
- *Bacillus anthracis*
- *Bartonella henselae, B. quintana, B. vinsonii*
- *Bordetella* including *B. pertussis*
- *Borrelia recurrentis, B. burgdorferi*
- *Burkholderia* (formerly *Pseudomonas* species) except those listed RG3 agents
- *Campylobacter coli, C. fetus, C. jejuni*
- *Chlamydia psittaci, C. trachomatis, C. pneumoniae*
- *Clostridium botulinum, Cl. chauvoei, Cl. haemolyticum, Cl. histolyticum, Cl. novyi, Cl. septicum, Cl. tetani*
- *Corynebacterium diphtheriae, C. pseudotuberculosis, C. renale*
- *Dermatophilus congolensis*
- *Edwardsiella tarda*
- *Erysipelothrix rhusiopathiae*
- *Escherichia coli* – all enteropathogenic, enterotoxigenic, enteroinvasive and strains bearing K1 antigen, including *E. coli* O157:H7
- *Haemophilus ducreyi, H. influenzae*
- *Helicobacter pylori*
- *Klebsiella* – all species except *K. oxytoca* (RG1)
- *Legionella* including *L. pneumophila*
- *Leptospira interrogans* – all serotypes
- *Listeria*
- *Moraxella*
- *Mycobacterium* (except agents specified in RG3) including *M. avium* complex, *M. asiaticum, M. bovis* BCG vaccine strain, *M. chelonei, M. fortuitum, M. kansasii, M. leprae, M. malmoense, M. marinum, M. paratuberculosis, M. scrofulaceum, M. simiae, M. szulgai, M. ulcerans, M. xenopi*
- *Mycoplasma*, except *M. mycoides* and *M. agalactiae* which are restricted animal pathogens
- *Neisseria gonorrhoeae, N. meningitides*
- *Nocardia asteroides, N. brasiliensis, N. otitidiscaviarum, N. transvalensis*
- *Rhodococcus equi*
- *Salmonella* including *S. arizonae, S. cholerasuis, S. enteritidis, S. gallinarum–pullorum, S. meleagridis, S. paratyphi,* A, B, C, *S. typhi, S. typhimurium*
- *Shigella* including *S. boydii, S. dysenteriae,* type 1, *S. flexneri, S. sonnei*
- *Sphaerophorus necrophorus*
- *Staphylococcus aureus*
- *Streptobacillus moniliformis*
- *Streptococcus* including *S. pneumoniae, S. pyogenes*
- *Treponema pallidum, T. carateum*
- *Vibrio cholerae, V. parahemolyticus, V. vulnificus*
- *Yersinia enterocolitica*

Fungal Agents

- *Blastomyces dermatitidis*
- *Cladosporium bantianum, C. (Xylohypha) trichoides*
- *Cryptococcus neoformans*
- *Dactylaria galopava (Ochroconis gallopavum)*
- *Epidermophyton*
- *Exophiala (Wangiella) dermatitidis*
- *Fonsecaea pedrosoi*
- *Microsporum*
- *Paracoccidioides braziliensis*
- *Penicillium marneffei*
- *Sporothrix schenckii*
- *Trichophyton*

Parasitic Agents

- *Ancylostoma* human hookworms including *A. duodenale, A. ceylanicum*
- *Ascaris* including *Ascaris lumbricoides suum*
- *Babesia* including *B. divergens, B. microti*
- *Brugia* filaria worms including *B. malayi, B. timori*
- *Coccidia*
- *Cryptosporidium* including *C. parvum*
- *Cysticercus cellulosae* (hydatid cyst, larva of *T. solium*)
- *Echinococcus* including *E. granulosis, E. multilocularis, E. vogeli*
- *Entamoeba histolytica*
- *Enterobius*
- *Fasciola* including *F. gigantica, F. hepatica*
- *Giardia* including *G. lamblia*
- *Heterophyes*
- *Hymenolepis* including *H. diminuta, H. nana*
- *Isospora*
- *Leishmania* including *L. braziliensis, L. donovani, L. ethiopia, L. major, L. mexicana, L. peruvania, L. tropica*
- *Loa loa* filaria worms
- *Microsporidium*
- *Naegleria fowleri*
- *Necator* human hookworms including *N. americanus*
- *Onchocerca* filaria worms including, *O. volvulus*
- *Plasmodium* including simian species, *P. cynomologi, P. falciparum, P. malariae, P. ovale, P. vivax*
- *Sarcocystis* including *S. sui hominis*
- *Schistosoma* including *S. haematobium, S. intercalatum, S. japonicum, S. mansoni, S. mekongi*
- *Strongyloides* including *S. stercoralis*
- *Taenia solium*
- *Toxocara* including *T. canis*
- *Toxoplasma* including *T. gondii*
- *Trichinella spiralis*

Viruses

Adenoviruses, human – all types

Alphaviruses (Togaviruses) – Group A Arboviruses
- Eastern equine encephalomyelitis virus
- Venezuelan equine encephalomyelitis vaccine strain TC–83
- Western equine encephalomyelitis virus

Arenaviruses
- Lymphocytic choriomeningitis virus (non–neurotropic strains)
- Tacaribe virus complex
- Other viruses as listed in the reference sources of the NIH guidelines

Bunyaviruses
- Bunyamwera virus
- Rift Valley fever virus vaccine strain MP–12
- Other viruses as listed in the reference sources of the NIH guidelines

Caliciviruses

Coronaviruses

Flaviviruses (Togaviruses) – Group B Arboviruses
- Dengue virus serotypes 1, 2, 3 and 4
- Yellow fever virus vaccine strain 17D
- Other viruses as listed in the reference sources of the NIH guidelines

Hepatitis A, B, C, D and E viruses

Herpesviruses – except Herpesvirus simiae (Monkey B virus) – [see RG4]
- Cytomegalovirus
- Epstein Barr virus
- *Herpes simplex* types 1 and 2
- *Herpes zoster*
- Human herpesvirus types 6 and 7

Orthomyxoviruses
- Influenza viruses types A, B and C
- Other tick–borne orthomyxoviruses as listed in the reference sources of the NIH guidelines

Papovaviruses
- All human papilloma viruses

Paramyxoviruses
- Newcastle disease virus
- Measles virus
- Mumps virus
- Parainfluenza viruses types 1, 2, 3 and 4
- Respiratory syncytial virus

Parvoviruses
- Human parvovirus (B19)

Picornaviruses
- Coxsackie viruses types A and B
- Echoviruses – all types
- Polioviruses – all types, wild and attenuated
- Rhinoviruses – all types

Poxviruses – all types except Monkeypox virus [see RG3] and restricted poxviruses including Alastrim, Smallpox and Whitepox

Reoviruses – all types including Coltivirus, human Rotavirus and Orbivirus (Colorado tick fever virus)

Rhabdoviruses
- Rabies virus – all strains
- Vesicular stomatitis virus – laboratory adapted strains including VSV–Indiana, San Juan and Glasgow

Togaviruses (see Alphaviruses and Flaviviruses)
- Rubivirus (rubella)

Source: NIH Guidelines for Research Involving Recombinant DNA Molecules.

Risk Group 3 (RG3) – Agents associated with serious or lethal disease for which preventative or therapeutic interventions *may be* available (work should be performed at BSL-3).

Bacterial Agents – Including Rickettsia

- *Bartonella*
- *Brucella* including *B. abortus, B. canis, B. suis*
- *Burkholderia (Pseudomonas) mallei, B. pseudomallei*
- *Coxiella burnetii*
- *Francisella tularensis*
- *Mycobacterium bovis* (except BCG strain, see *RG2) – (Including Chlamydia*), *M. tuberculosis*
- *Pasteurella multocida* type B – "buffalo" and other virulent strains
- Rickettsia akari, R. australis, R. canada, R. conorii, R. prowazekii, R. rickettsii, R, siberica, R. tsutsugamushi, R. typhi (R. mooseri)
- *Yersinia pestis*

Fungal Agents

- *Coccidioides immitis* (sporulating cultures; contaminated soil)
- *Histoplasma capsulatum, H. capsulatum var.. duboisii*

Parasitic Agents

None

Viruses and Prions

Alphaviruses (Togaviruses) – Group A Arboviruses
- Semliki Forest virus
- St. Louis encephalitis virus
- Venezuelan equine encephalomyelitis virus (except the vaccine strain TC–83, see RG2)
- Other viruses as listed in the reference sources in the NIH guidelines

Arenaviruses
- Flexal
- Lymphocytic choriomeningitis virus (LCM) (neurotropic strains)

Bunyaviruses
- Hantaviruses including Hantaan virus
- Rift Valley fever virus

Flaviviruses (Togaviruses) – Group B Arboviruses
- Japanese encephalitis virus
- Yellow fever virus
- Other viruses as listed in the reference sources in the NIH guidelines

Poxviruses
- Monkeypox virus
- Prions
- Transmissible spongioform encephalopathies (TME) agents (Creutzfeldt–Jacob disease and kuru agents)
- ***Retroviruses***
- Human immunodeficiency virus (HIV) types 1 and 2
- Human T cell lymphotropic virus (HTLV) types 1 and 2
- Simian immunodeficiency virus (SIV)

Rhabdoviruses
- Vesicular stomatitis virus

Source: NIH Guidelines for Research Involving Recombinant DNA Molecules.

Risk Group 4 – Agents are likely to cause serious or lethal human disease for which preventive or therapeutic interventions are *not usually* available (work should be performed at BSL-4).

Bacterial Agents

None

Fungal Agents

None

Parasitic Agents

None

Viral Agents

Arenaviruses
- Guanarito virus
- Lassa virus
- Junin virus
- Machupo virus
- Sabia

Bunyaviruses (Nairovirus)
- Crimean–Congo hemorrhagic fever virus

Filoviruses
- Ebola virus
- Marburg virus

Flaviruses (Togaviruses) – Group B Arboviruses
- Tick–borne encephalitis virus complex including Absetterov, Central European encephalitis, Hanzalova, Hypr, Kumlinge, Kyasanur Forest disease, Omsk hemorrhagic fever and Russian spring–summer encephalitis viruses

Herpesviruses (alpha)
- Herpesvirus simiae (Herpes B or Monkey B virus)

Paramyxoviruses
- Equine morbillivirus
- *Trypanosoma* including *T. brucei brucei, T. brucei gambiense, T. brucei rhodesiense, T. cruzi*
- *Wuchereria bancrofti* filaria worms

Source: NIH Guidelines for Research Involving Recombinant DNA Molecules.

Appendix Y – OSHA Laboratory Standard

1910.1450(a)

Scope and application.

1910.1450(a)(1)

This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

1910.1450(a)(2)

Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

1910.1450(a)(2)(i)

For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

1910.1450(a)(2)(ii)

Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

1910.1450(a)(2)(iii)

Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

1910.1450(a)(3)

This section shall not apply to:

..1910.1450(a)(3)(i)

1910.1450(a)(3)(i)

Uses of hazardous chemicals which do not meet the definition of laboratory use and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart 2, even if such use occurs in a laboratory.

1910.1450(a)(3)(ii)

Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

1910.1450(a)(3)(ii)(A)

Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

1910.1450(a)(3)(ii)(B)

Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

1910.1450(b)

Definitions -

"Action level" means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor or designee.

"Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

"Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C) or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

"Designated area" means an area which 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.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"Employee" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas and heat when subjected to sudden shock, pressure or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change or retained heat from manufacturing or processing or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C) or that contain suspended solids or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)).

Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems and agents which damage the lungs, skin, eyes or mucous membranes.

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

"Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

"Laboratory scale" means work with substances in which the containers used for reactions, transfers and other handling of substances are designed to be easily and safety manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to

draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"Medical consultation" means a consultation which takes place between an employee 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.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence tat it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

"Protective laboratory practices and equipment" means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

"Reproductive toxins" means chemicals which affect the reproductive chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which is the pure state or as produced or transported, will vigorously polymerize, decompose, condense or will become self-reactive under conditions of shocks, pressure or temperature.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

1910.1450(c)

Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

..1910.1450(d)

1910.1450(d)

Employee exposure determination -

1910.1450(d)(1)

Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

1910.1450(d)(2)

Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over

the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

1910.1450(d)(3)

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

1910.1450(d)(4)

Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

1910.1450(e)

Chemical hygiene plan - General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan).

1910.1450(e)(1)

Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

1910.1450(e)(1)(i)

Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

..1910.1450(e)(1)(ii)

1910.1450(e)(1)(ii)

Capable of keeping exposures below the limits specified in paragraph (c) of this section.

1910.1450(e)(2)

The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

1910.1450(e)(3)

The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;

1910.1450(e)(3)(i)

Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

1910.1450(e)(3)(ii)

Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

1910.1450(e)(3)(iii)

A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

..1910.1450(e)(3)(iv)

1910.1450(e)(3)(iv)

Provisions for employee information and training as prescribed in paragraph (f) of this section;

1910.1450(e)(3)(v)

The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

1910.1450(e)(3)(vi)

Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

1910.1450(e)(3)(vii)

Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee; and

1910.1450(e)(3)(viii)

Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

1910.1450(e)(3)(viii)(A)

Establishment of a designated area;

1910.1450(e)(3)(viii)(B)

Use of containment devices such as fume hoods or glove boxes;

1910.1450(e)(3)(viii)(C)

Procedures for safe removal of contaminated waste; and

..1910.1450(e)(3)(viii)(D)

1910.1450(e)(3)(viii)(D)

Decontamination procedures.

1910.1450(e)(4)

The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

1910.1450(f)

Employee information and training.

1910.1450(f)(1)

The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

1910.1450(f)(2)

Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

1910.1450(f)(3)

Information. Employees shall be informed of:

1910.1450(f)(3)(i)

The contents of this standard and its appendices which shall be made available to employees;

1910.1450(f)(3)(ii)

the location and availability of the employer's Chemical Hygiene Plan;

..1910.1450(f)(3)(iii)

1910.1450(f)(3)(iii)

The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

1910.1450(f)(3)(iv)

Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

1910.1450(f)(3)(v)

The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

1910.1450(f)(4)

Training.

1910.1450(f)(4)(i)

Employee training shall include:

1910.1450(f)(4)(i)(A)

Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

1910.1450(f)(4)(i)(B)

The physical and health hazards of chemicals in the work area; and

1910.1450(f)(4)(i)(C)

The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures and personal protective equipment to be used.

..1910.1450(f)(4)(ii)

1910.1450(f)(4)(ii)

The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

1910.1450(g)

Medical consultation and medical examinations.

1910.1450(g)(1)

The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

1910.1450(g)(1)(i)

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.

1910.1450(g)(1)(ii)

Where 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 for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

1910.1450(g)(1)(iii)

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.

..1910.1450(g)(2)

1910.1450(g)(2)

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.

1910.1450(g)(3)

Information provided to the physician. The employer shall provide the following information to the physician:

1910.1450(g)(3)(i)

The identity of the hazardous chemical(s) to which the employee may have been exposed;

1910.1450(g)(3)(ii)

A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

1910.1450(g)(3)(iii)

A description of the signs and symptoms of exposure that the employee is experiencing, if any.

1910.1450(g)(4)

Physician's written opinion.

1910.1450(g)(4)(i)

For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

1910.1450(g)(4)(i)(A)

Any recommendation for further medical follow-up;

1910.1450(g)(4)(i)(B)

The results of the medical examination and any associated tests;

..1910.1450(g)(4)(i)(C)

1910.1450(g)(4)(i)(C)

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 workplace; and

1910.1450(g)(4)(i)(D)

A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

1910.1450(g)(4)(ii)

The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

1910.1450(h)

Hazard identification.

1910.1450(h)(1)

With respect to labels and material safety data sheets:

1910.1450(h)(1)(i)

Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

1910.1450(h)(1)(ii)

Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals and ensure that they are readily accessible to laboratory employees.

1910.1450(h)(2)

The following provisions shall apply to chemical substances developed in the laboratory:

..1910.1450(h)(2)(i)

1910.1450(h)(2)(i)

If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

1910.1450(h)(2)(ii)

If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

1910.1450(h)(2)(iii)

If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

1910.1450(i)

Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

1910.1450(j)

Recordkeeping.

1910.1450(j)(1)

The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

..1910.1450(j)(2)

1910.1450(j)(2)

The employer shall assure that such records are kept, transferred and made available in accordance with 29 CFR 1910.1020.

1910.1450(k)

Dates -

1910.1450(k)(1)

Effective date. This section shall become effective May 1, 1990.

1910.1450(k)(2)

Start-up dates.

1910.1450(k)(2)(i)

Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

1910.1450(k)(2)(ii)

Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

1910.1450(l)

Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

[61 FR 5507, Feb. 13, 1996]

Appendix Z –Laboratory Check Out/Check In Forms

LABORATORY CHECK-OUT FORM	Completed			Date Completed	Questions
GENERAL					
Contact EHS at least one month prior to lab move.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Remove ***Caution Door Signs*** when lab is vacated and all hazardous materials have been removed.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Ensure that laboratory personnel have decontaminated all potentially contaminated surfaces (chemical, biological or radiological contaminants).	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Ensure that potential ***asbestos containing materials*** (e.g. lab ovens, benchtops) are tested prior to disposal. Contact EHS if you have any questions.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Collapse uncontaminated, unwanted cardboard boxes for recycling. Alert **Custodial Services** when bundled cardboard is ready for removal.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-2656
Indicate who will assume ownership of chemicals that are left behind (if any). Name: _____	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Ensure that all unwanted chemicals are added to the UNHCEMS™ website.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
HAZARDOUS WASTE					
Ensure that all hazardous waste containers have a completed UNH hazardous waste label including proper identification of contents.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Ensure that all hazardous waste is removed prior to last day of occupancy.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Return all gas cylinders and lecture bottles to their respective vendors.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Retrieve all mercury-containing devices for waste pickup by EHS if they will not be taken with PI.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
BIOLOGICAL SAFETY					
Notify EHS to inactivate IBC registered activities.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Ensure that biosafety cabinet surfaces have been decontaminated and cleaned (or call a vendor to decontaminate).	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Decontaminate biological safety cabinet filters or replace with new HEPA filters.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Remove all biological materials from storage equipment. Decontaminate surfaces with an appropriate disinfectant. Remove all biological stickers from equipment after decontamination.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Ensure that all biological waste has been packaged, sealed and labeled before removal.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Ensure that all contaminated sharps are enclosed within ***Sharps*** containers. Place the ***Sharps*** container in a burn box and dispose as biological waste. Do not leave any sharps in the laboratory.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
RADIATION SAFETY					
Notify EHS 30 days before terminating work with any radionuclides.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3607
All equipment that has been subject to radioisotope exposure must be inspected and formally released by EHS.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3607
Ensure that all equipment that has been subject to radioisotope exposure is inspected and formally released by EHS.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3607
ELECTRICAL SAFETY					
Bleed any stored energy from electrical equipment bound for the trash.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4761
Have any electrical or computer equipment for disposal approved by Purchasing. http://www.unh.edu/purchasing/surplus/surplus_scrap.html.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526

LABORATORY CHECK-IN FORM	Status			Date Completed	Questions
GENERAL					
Provide copies of the ***UNH Laboratory Safety Plan*** to individuals in the laboratory. This document is available online at http://www.unh.edu/ehs/biological-safety.htm.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Ensure your chemical inventory is included in UNHCEMS™ (http://www.cems.sr.unh.edu).	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Ensure that lab personnel understand where and how to obtain chemicals.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Ensure that lab personnel know where ***Material Safety Data Sheets*** (MSDS) are located (http://www.cems.sr.unh.edu).	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Ensure that appropriate personal protective equipment is worn in the laboratory.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Complete a ***Caution Sign*** for each laboratory door.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
Provide lab emergency contact information to EHS.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-1510
HAZARDOUS WASTE					
Obtain a copy of the ***UNH Hazardous Waste Management Plan***. This document is available online at http://www.unh.edu/ehs/waste-management.htm.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Contact EHS to establish hazardous waste ***Satellite Accumulation Areas (SAAs)***.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Contact EHS for biological/infectious waste containers and to establish collection schedule.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
Ensure that individuals do not bring mercury-containing thermometers or devices into University facilities (unless scientific justification has been shown).	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3526
BIOLOGICAL SAFETY					
Clean and certify all biological safety cabinets prior to usage. (An outside vendor is used to certify biological safety cabinets at UNH. Call EHS for more information.)	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Ensure that personnel have completed ***Biological Safety and Sharps Training*** prior to beginning any laboratory activities.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Register all use of infectious material, human cell lines, materials, tissue, blood, and recombinant DNA with the UNH IBC at http://www.unh.edu/ehs/biological-safety.htm.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Contact the UNH Responsible Official prior to receiving, shipping, or using CDC Select Agents or USDA High Consequence Livestock Pathogens or Toxins. Register all use of Select Agents with the UNH Office of Environmental Health and Safety.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Register with CDC/USDA before receiving or transferring Select Agents or High Consequence Livestock Pathogens or Toxins. Call the biosafety officer for more information.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4041
Submit protocols using vertebrate animals to UNH ***IACUC*** for review prior to commencing.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-4629
Submit protocols using human subjects to UNH ***IRB*** for review prior to commencing.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-2003
RADIATION SAFETY					
If you want to use radioactive materials, complete the ***Radiation Permit Application*** available at http://www.unh.edu/ehs/radiation-safety.htm.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-3607
SHIPPING SAFETY					
If lab will be shipping chemical, biological, or radiological samples or materials, responsible lab personnel must complete ***Shipping Training***.	☐ Yes	☐ No	☐ N/A	____ / ____ / _____	862-5038

This form must be printed on PINK colored paper.

Maintenance Entry Approval Form

To ensure the safe entry into laboratories and other areas containing hazardous materials, the following information is needed from the individual responsible for the area in question.

NOTE TO PRINCIPAL INVESTIGATORS

Work on this project will not begin until the area is determined to be safe for maintenance personnel to enter.

Description of work to be performed (include equipment description): _____

_____

Building: _____ Room(s): _____

Contact Person: _____ Telephone #: _____

Hazardous conditions: _____

_____

Have all hazardous materials (i.e. chemicals) been moved away from the work area? *Yes* ☐ *No* ☐

Have all areas been decontaminated in preparation for entry? *Yes* ☐ *No* ☐

Safety equipment needed (check all that apply):

Gloves ☐ *Safety glasses* ☐ *Respirator* ☐ *Hearing protection* ☐ *Protective clothing* ☐

Authorized start date/time: _____

Principal Investigator: _____ **Date:** _____ **Time:** _____

Once complete, POST on door where work will commence.

This section to be completed by Facilities Services.

Maintenance Request # _____

Start date/time: _____

Anticipated completion date/time: _____

WORK COMPLETED BY MAINTENANCE: *Yes* ☐ *No* ☐ **IF NO, PLEASE EXPLAIN:**

_____

Technician Signature: _____ ***Date:*** _____

Return to Facilities Services, Leavitt Center, when complete.