Department of
Environmental
Health & Radiation
Safety

Laboratory Safety Manual

2025

"Safety is a Personal Decision that Impacts other on a Daily Basis"

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I. Mission Statement

Our faculty, staff and students bring a wealth of expertise to our institutions. They are vital to our mission of research, teaching and service to everyone within and outside of our university's community. This expertise requires our institution to demonstrate its leadership in providing health protection and apply safety standards beyond the laws and regulations relating to environment, health and safety.

Our mission is to prevent or minimize injuries and illnesses and control potential hazards from our activities. Our intentions are to continually consult with each of the departments for complete compliance with laws and regulations regarding occupational health and safety and environmental protection. This Laboratory Safety Manual is intended to inform our researchers of the policies and procedures of the university in an effort to provide protection to university employees, students, research subjects and our community. The manual details carefully developed compliance strategies, which include training, periodic inspections, sanitation, radiation protection, hazardous material handling, hazardous waste management, general safety, occupational health, disaster preparation and reporting of unauthorized potentially hazardous activities.

We must all remember that good environmental health and safety practices are a responsibility of each faculty member, staff member, student and visitor. Our participation and adherence to regulatory compliance is essential to smooth and effective operation of an environmental health and safety program. Achievement of these goals is critical for the growth of our university. The Office of Research and the Department of Environmental Health and Radiation Safety (EHRS) welcome your suggestions and cooperation in making our university the safest place to work.

II. Important Contact Numbers

Department	Center City Campus	University Campus	Queen Lane Campus	Elkins Park Campus	ANS Campus	West Reading Campus
Public Safety Call Center	267-359-2380	215-895-2222	215-895-2222	215-780-1401	215-299-1019	484-659-8100
EHRS	215-895-5919	215-895-5919	215-895-5919	215-895-5919	215-895-5919	215-895-5919
Office of Research	215-895-5849	215-895-6091	215-895-5849	215-895-5849	215-895-5849	215-895-5849
Facilities Management	215-895-1700	215-895-1700	215-991-8484	215-780-1410	215-299-1030	484-659-8100
Employee Health	215-762-8525	215-762-8525	215-762-8525	215-762-8525	215-762-8525	215-762-8525
Student Health	215-895-5800	215-895-5800	215-895-5800	215-895-5800	215-895-5800	215-895-5800
Radiation Safety	215-895-5919	215-762-4050	215-762-4050	215-895-5919	215-895-5919	215-895-5919
University Biosafety Officer	215-895-5891	215-895-5891	215-895-5891	215-895-5891	215-895-5891	215-895-5891
University Chemical Hygiene Officer	215-895-5892	215-895-5892	215-895-5892	215-895-5892	215-895-5892	215-895-5892
Recombinant DNA Officer	215-762-7398	215-762-7398	215-762-7398	215-762-7398	215-762-7398	215-762-7398
Laser Safety Officer	215-895-5913	215-895-5913	215-895-5913	215-895-5913	215-895-5913	215-895-5913

III. Introduction

Drexel University is committed to promoting a health and safe working place and safe work practices for its faculty, staff, students and visitors. At Drexel University, laboratory safety program depends on everyone's participation and cooperation and their commitment to perform their laboratory functions in a way that is safe for themselves and their coworkers. Failure to follow safety precautions not only exposes the individual to risks, but often compromises the safety of fellow workers and the surrounding community, and may result in loss and/or damage.

The laboratory safety program at Drexel University is committed to meet the requirements of the federal laboratory safety standards, which is intended to safely limit laboratory workers' exposure to hazardous substances. Laboratory workers must not be exposed to substances in excess of the permissible exposure limits (PEL) specified in Occupational Safety and Health Administration (OSHA) rule 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances. Likewise, the Toxic Substances Control ACT administered by the U.S. Environmental Protection Agency requires that prudent laboratory practices be developed and documented for research involving new chemicals that have not had their health and environmental hazards fully characterized. OSHA's Occupational Exposure to hazardous Chemicals in laboratories standard (29 CFR 1910.1450), referred to as the Laboratory Standard, cover the laboratories where chemical manipulation generally involves small amounts of a limited variety of chemicals. This standard applies to all hazardous chemical meeting the definition of "laboratory use" and having the potential for worker exposure. The OSHA (29 CFR 1910.1200) and Pennsylvania Worker and Community Right to Know standards require communicating information about hazardous materials used, produced or stored at work sites within the Commonwealth. These laws and Acts provide minimum standards that employees must adhere to and responsibilities of the employer for informing employees about occupational-health hazards in the workplace.

Over the past two decades, *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) has become the code of practice for biosafety—the discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. The principles of biosafety introduced in 1984 in the first edition of BMBL1 and carried through in this fifth edition remain steadfast. These principles are containment and risk assessment. The fundamentals of containment include the microbiological practices, safety equipment, and facility safeguards that protect laboratory workers, the environment, and the public from exposure to infectious microorganisms that are handled and stored in the laboratory. Risk assessment is the process that enables the appropriate selection of microbiological practices, safety equipment, and facility safeguards that can prevent laboratory-associated infections. The purpose of periodic updates of BMBL is to refine guidance based on new knowledge and experiences and to address contemporary issues that present new risks that confront laboratory workers and the public health. In this way, the code of practice will continue to serve the microbiological and biomedical community as a relevant and valuable authoritative reference.

The purpose of Drexel's program is to inform and train the employees specifically about chemicals and other hazardous substances used in processes at the laboratory. This Laboratory Safety Program includes policies procedures for the use of personal protective equipment, practices that minimize the risk of injury or illness and ensures that employees have the training, information, support they need to wok safely in the laboratory. The program also covers a wide spectrum of safety precautions ranging from daily housekeeping responsibilities to procedures to follow in emergency situations addressing specific issues related to general laboratory practices, biological safety, chemical safety, radiation safety and emergency procedures.

As a Drexel employee, it is your right and responsibility to follow the rules of laboratory safety. It is your responsibility to read and understand the information contained in the manual and to keep the manual readily accessible for review and emergency use. It will be updated as new safety information or governmental regulations are obtained. This manual is to be used as an informational resource. The manual is not a contract, nor a legal document. Drexel University reserves the right to delete, add or amend the contents of this manual. Occupational hazards and regulatory rules will undoubtedly continue to be changed. Accordingly, no representation can be made or responsibility undertaken by Drexel University regarding the completeness, accuracy or continuing validity of the contents of the is manual.
In the final analysis, each employee must assume his or her responsibility to work in a safe manner hereby avoiding personal harm or endangering others.

IV. Right to Know Guidelines

Biological and chemical research often requires the use of hazardous materials including radioisotopes, infectious agents, and hazardous chemicals. While working at Drexel University it is likely that you will be required to handle such materials. In this regard, it will be your specific right and obligation to know, before using a hazardous material in an experiment, what is the nature of the material, its specific hazard and the proper procedures for its use.

If you are ever in doubt or have a problem with the use of any material or have a complaint about experiments done by others, here are the procedures to follow.

1. Discuss the problem with your immediate supervisor.
2. If you are not satisfied, discuss with the department chair.
3. If you are not satisfied, then discuss the problem with EHRS.
4. If still unsatisfied, contact the Laboratory Safety Committee.
5. If still unsatisfied, request a meeting with the Senior Associate Vice-Provost for Research compliance.
6. If still unsatisfied, request a meeting with Senior Vice-Provost for Research.
7. Drexel University has also established a compliance hotline to make it easy for anyone to report conduct that might violate the law, University policy or the University Code of Conduct.

A. Information for Laboratory Workers

It is essential that laboratory employees have access to information on the hazards of chemicals and procedures for working safely. Supervisors must ensure that laboratory employees are informed about and have access to the following information sources:

1. **The contents of the OSHA Laboratory Safety Standard**
2. "Occupational Exposure to Hazardous Chemicals in Laboratories" and its appendices (29 CFR 1910.1450).
3. **The Drexel University Laboratory Safety Manual** is available to all employees on the EHRS's website. Individual department Laboratory Safety Plans are available within those departments.
4. **The Permissible Exposure Limits (PELs).** The Occupational Safety and Health Administration (OSHA) developed PELs for specific regulated substances. These are the legal limit for exposure of an employee to a chemical substance or physical agent such as loud noise.
5. **Signs and symptoms associated with exposures to hazardous chemicals.** Laboratory Chemical Safety Summaries (LCSSs) are similar to Safety Data Sheets (SDS) but are tailored to the hazards of laboratory use of those chemicals. The LCSSs include toxicity information, and signs and symptoms of exposure to the chemicals. In addition, the National Institute of Occupation Safety

and Health (NIOSH) publishes a pocket guide to chemical hazards. This guide provides information about the chemical, the exposure limits, exposure routes, and the symptoms associated with exposure.

6. Safety Data Sheets (SDSs) are available online through links from the EHRS website. Individual researchers are encouraged to keep hard copies in an easily accessible location for materials that are used in large quantities, which are used frequently, or which are particularly toxic.
7. Information on chemical waste disposal and spill response is located in Parts II and III of this manual. Additional, information regarding proper disposal of hazardous waste can be found in the Hazardous Waste Management Plan on EHRS website.
8. Information and resources for new PIs and Laboratory workers can found on the EHRS website.

V. Roles and Responsibilities

Implementation of laboratory safety standards at the university is a shared responsibility of employees, supervisors, department heads, deans, senior administrative staff and EHRS.

A. President, Provost and Senior Vice Provost for Research

- The responsibility to promote the importance of safety.
- Promoting the attitude and culture of safety among the university employees.
- Supporting the safety program that will protect employees from the effects of biological, chemical agents.
- Ensuring that the deans, directors, department heads provide adequate time and recognition for the employees who carry safety responsibilities.
- Review annual EHRS reports of the level of compliance within each of the reporting units.

B. Deans, Directors and Department Heads

- Identifying a technically qualified Laboratory Safety Liaisons (LSL) for the unit.
- Large departments may have more than one laboratory safety liaison.
- Ensuring that these safety liaisons are properly trained.
- Ensuring that the safety liaisons have adequate time to conduct periodic safety checks.
- Evaluating the performance of Laboratory Safety Manual (LSM).
- Taking appropriate measures to assure that the college/department/division activities comply with university and federal, state and local safety policies.

C. Department Chemical Hygiene Officers

- Ensuring all activities related to the use of hazardous chemicals in laboratories is conducted in a safe manner as well as in compliance with OSHA regulations as specified in 29 CFR Part 1910.1450.
- Providing reports at the department Safety Committee meetings on chemical hygiene activities performed.
- Working with principal investigator's (PI's) to develop, review and approve Job Hazard Analysis, Risk Assessments, and Standard Operating Procedures detailing all aspects of proposed research activities that involve hazardous materials.
- Working with the PI's on the approval process for the purchase of highly toxic, reactive, or carcinogenic or other inherently hazardous materials.

- Investigating and completing a report for chemical related incidents and exposures in their department.
- Providing guidance with personal protective equipment selection based on the findings in the job hazard analysis and risk assessment.
- Working as a liaison with the University Chemical Hygiene Officer and the Department of Environmental Health & Safety to ensure compliance.
- Disseminating chemical safety information throughout their department through emails, posting, and other forms of communications.
- Providing general chemical safety guidance to department staff, students and faculty.
- Making copies of the approved Chemical Hygiene Plan available to the program and support staff.
- Facilitating the use of the Laboratory Management Program by the Principal Investigators.
- Facilitating Chemical Hygiene Plan training for all laboratory workers in the department.

D. Laboratory Safety Liaisons

- Acting as a liaison between the employing unit and EHRS.
- Knowing the rules to assist the researchers in complying with safety requirements.
- Assisting the investigators in developing a safety plan for their laboratories.
- Coordinating and tracking training.

E. PI or Instructor in the teaching laboratory

- PI or Instructor in the teaching laboratory has responsibility for the health and safety of all laboratory personnel working in their laboratory.
- The PI or Instructor may delegate the safety duties for which they are responsible but must ensure delegated safety duties are adequately performed by periodically checking the performance.
- Knowing all applicable health and safety rules and regulations, training and reporting requirements and standard operating procedures associated with laboratory safety.
- Identifying hazardous conditions or operations in the lab, determining safe procedures and controls, and implementing and enforcing standard safety procedures.
- Establishing standard safety operating procedures (general and protocol specific) and performing literature searches relevant to health and safety that is appropriate for the work.
- Consulting with EHRS on use of high-risk materials (not routine) such as use of particularly hazardous chemicals, biologics, toxins, select agents or conducting high risk experimental procedures so that special safety precautions may be taken.
- Maintaining an updated chemical and hazardous material inventory and MSDS sheets for the laboratory.
- Ensuring laboratory personnel under his/her supervision have access to and are familiar with the appropriate Laboratory Safety Manual(s).
- Training all laboratory personnel, he/she supervises to work safely with hazardous materials and maintain records of laboratory specific training in the BioRAFT Compliance Platform. Training must include informing laboratory personnel of the location and availability of Hazard Information.
- Promptly notifying EHRS and/or Facilities Management should he/she become aware that workplace engineering controls (e.g., fume hoods) and safety equipment (e.g., emergency showers/eyewashes, fire extinguishers, etc.) become nonoperational.
- Ensuring the provision and maintaining in functional working order all appropriate personal protective equipment (PPE) (e.g., lab coats, gloves, eye protection, etc.).
- Conducting monthly self-inspections of laboratory and maintaining records of inspections, as required.

- Prompt reporting of laboratory accidents and injuries to Risk Management and EHRS. Serious injuries MUST be immediately reported to EHRS.
- Informing EHRS and facilities personnel, of potential lab-related hazards.
- Identifying and minimizing potential hazards to provide a safe environment for repairs and renovations.
- Maintaining an accurate lab member and hazard list in BioRAFT.

F. Personnel responsibilities

- Reviewing and following relevant laboratory safety manual(s).
- If applicable, reviewing and following Radiation Safety and Biosafety Manuals.
- Following oral and written laboratory safety rules, regulations, and standard operating procedures required for the tasks assigned.
- Keeping the work areas safe and uncluttered.
- Reviewing and understanding the hazards of materials and processes in their laboratory research or experiment prior to initiating work.
- Utilizing appropriate measures to control identified hazards, including consistent and proper use of engineering controls, personal protective equipment, and administrative controls.
- Understanding the capabilities and limitations of PPE issued to them.
- Gaining prior approval from the PI/Laboratory Supervisor for the use of restricted chemicals and other materials.
- Consulting with PI/Laboratory Supervisors before using highly hazardous materials or conducting certain high risk experimental procedures.
- Promptly reporting accidents and unsafe conditions to the PI/Laboratory Supervisor or Faculty.
- Completing all required health, safety and environmental training specific to the laboratory and providing written documentation to their supervisor.
- Participating in the Occupational Safety and Health Program, when required.
- Informing the PI/ Laboratory Supervisor of any work modifications ordered by a physician as a result of medical surveillance, occupational injury or exposure.
- Laboratory personnel working autonomously or performing independent research are also responsible for:
    - Reviewing the plan or scope of work for their proposed research with the PI/Laboratory Supervisor or Faculty;
    - Notifying in writing and consulting with the PI/Laboratory Supervisor or Faculty, in advance, if they intend to deviate from their scope or scale of work;
    - Preparing SOPs and performing literature searches relevant to safety and health that are appropriate for their work and
    - Providing appropriate oversight, training and safety information to laboratory personnel they supervise or direct.

G. Environmental Health and Radiation Safety

- EHRS staff will participate in providing resources for departments in the development of their individual health and safety programs.
- Identifying and assessing potentially hazardous operations.
- Developing risk management strategies.
- Preparing and updating the University's Laboratory Safety Manual (LSM).
- Distributing the LSM to departments and other units and assisting them in tailoring and implementing the plan.

- Training LSLs regarding their responsibilities for safety and compliance with regulations in their respective units.
- Providing safety training and awareness information to laboratory work force including students on laboratory safe practices.
- Monitoring and conducting semi-annual and unannounced safety audits toward achieving compliant safety practices.
- Serving as the primary liaison to environmental health and safety regulatory agencies.
- Assisting the university in responding to regulatory agencies in matters of investigations, employee complaints, or potential or actual regulatory enforcement actions.
- Consulting with colleges, schools, departments and affiliated units and the office of the general counsel to ensure a unified and consistent University response to a governmental inquiry, complaint or lawsuit
- EHRS may also provide specialized or dedicated operational services to schools and departments through expense recovery arrangements.

H. Management

- The Laboratory Safety Committee (LSC) appointed by the Senior Vice -Provost of Research serves as the primary stakeholder body to review and endorse the scope of services provided by EHRS to the University community.
- This committee seeks consensus among its membership to ensure consistency in approach and implementation of compliance programs and services throughout the University.
- LSC may meet on a quarterly basis to review environmental health and safety risks and applicable regulatory requirements, standards and best practices.
- LSC consults with other University stakeholders, as appropriate, and advises EHRS in the development of plans, procedures and implementation strategies to ensure compliance and mitigate adverse impacts to the University.
- LSC chair and committee members are appointed by the Senior Vice Provost for Research. The actual number of committee members may vary depending upon the need.
- LSC includes representation from the schools, departments or others with specific subject matter expertise from various departments. The Director of EHRS is a member of the committee.
- The Committee may convene subcommittees to address stakeholder-specific functions or issues (e.g., laboratory safety, facility safety, new regulations, auditing processes, personal protective equipment).
- LSC subcommittee may include members other than the primary LSC members for the purpose of bringing additional expertise for discussions

I. Students

- Comply with university health and safety practices by maintaining class, work, and laboratory areas safe and free from hazards.
- Wear appropriate laboratory personnel protective equipment (lab coats, safety goggles and other required equipment) when working in the laboratory.
- Complete required health and safety training prior to working in a laboratory.
- Inform a supervisor or instructor of any safety hazards in the workplace, classroom, or laboratory.

J. Incident Reporting

Any time an employee is injured at work, it is critical that the incident be reported, recorded and investigated properly. Recording and investigating the incident is necessary for developing strategies to prevent a similar incident from reoccurring.

- The University has the responsibility to investigate and appropriately report environmental health and safety incidents.
- Employees, students, and others affiliated with the University have the responsibility to disclose any activity that may be, or may result in, a violation of any environmental health and safety regulation.
- All personnel should immediately notify appropriate emergency responders (e.g. University Public Safety department, fire department and EHRS) of any situation that may result in an imminent hazard to persons, property or the environment.
- EHRS provides regulatory liaison, technical assistance and operational guidance as requested or required, and works with the school and emergency responders to establish safety and other criteria for resumption of normal operations.
- All employees, students and others affiliated with the University are expected to fully cooperate, and participate as appropriate, in the investigation and remediation of any incidents.
- Employees and students who report incidents in accordance with law and University procedures, or who raise questions or concerns about the University's environmental health and safety procedures, will not be penalized, and such action will not be recorded in the employee's or student's record.
- Drexel University has also implemented an emergency notification system called DrexelAlert, which is designed to disseminate critical information to the Drexel community via email, voicemail and text messaging.

Drexel University views compliance with all laws, regulations, and University policies as conditions of employment, and of academic eligibility. Violation of such requirements shall be considered grounds for disciplinary action, including termination of employment and/or enrollment status. Governmental agencies have established strict policies to ensure compliance with environmental health and safety regulations, including civil penalties and individual criminal penalties leading to possible prosecution, imprisonment and substantial fines. Accordingly, the University expects all faculty, staff, postdoctoral scholars, and students and University affiliates to be vigilant in complying with all environmental health and safety requirements, and to acquire the information they need to properly conduct their activities at the University.

VI. Laboratory Safety Training

All laboratory researchers must be trained according to the requirements of the Laboratory Safety Standard. Colleges and non-academic departments that engage in the laboratory use of hazardous chemical, physical or biological agents are responsible for identifying such employees. The employees must be informed about their roles and responsibilities as outlined in this Part, as well as hazards associated with their work and how to work safely and mitigate those hazards.

EHRS has prepared several web-based training programs that provides basic information for working safely with chemicals, biologics, toxins and carcinogenic agents. The required training depends upon the work and materials involved, including use of radioactive materials, biological materials, lasers, irradiators and use of respirators or self-contained breathing apparatus. The training courses are available online as well as classroom training courses as needed. The online training courses are available at the following link: drexel.bioraft.com using your Drexel Credentials. The laboratory safety training curriculum includes:

- Biological Safety
- Chemical Hygiene
- Compressed Gas Safety
- Electrical Safety
- Emergency Response
- Fire and Life Safety
- Hazard Communication
- Hazardous Waste Management
- Hydrofluoric Acid Safety
- Laboratory Equipment Safety
- Laser Safety
- Mercury Safety
- Needle Stick and Needle Safety
- Personal Protection Equipment
- Reactive Chemicals and Pyrophoric Safety
- Radiation Safety
- Recombinant DNA Materials
- Respiratory Protection
- Shipping Biological Materials
- Ergonomics
- Isoflurane

Training courses are assigned to each lab member based on a job activity assessment. The Principal Investigator is responsible for conducting the job activity assessment. The BioRAFT platform will notify all lab members when training is due. Notifications will be sent to the PI and Department Head when an individual's training is overdue. The notification timeline is as follows:

- **1 month Warning Message** – This message is sent to inform the user that a training course is due in one month.
- **2-week Warning Message** – This message is sent to inform the user that a training course is due in two weeks.
- **3-day Warning Message** – This message is sent to inform the user that a training course is due in three days.
- **Digest Style Message** – This message is sent to inform the user that their training is overdue. This message is sent on a weekly basis until the user completes the training.
- **Overdue Message to Supervisor** – This message is sent to a supervisor to inform them that one of their lab members has overdue training. This message is sent on a weekly basis until the training is completed.
- **Overdue Digest Message to EHS** – This message is sent to EHS to inform them that a researcher has overdue training. This message is sent on a weekly basis until the training is completed.

In addition, each laboratory LSL is responsible for ensuring that laboratory employees are provided with training about the specific hazards present in their laboratory work area, and methods to control such hazards. Such training must be provided at the time of an employee's initial assignment to a work area and prior to assignments involving new potential exposures and must be documented. Refresher training must be provided at least annually. The specific training must be documented and upload into the BioRAFT Compliance Platform.

A. Laboratory Closure Timeline for Training Non-Compliance

EHRS will send a closure notice to the PI if any lab member has one or more training courses overdue for two weeks or more. The notice will provide the names of the lab member who are delinquent and a deadline date to complete. The deadline to complete will be no more than 24 hours. The lab will be closed if the training is not completed prior to the deadline. The lab will remain closed until all training is completed.

B. Suspension of Laboratory Access for Research Operations

EHRS will send an access suspension notice to the PI if any lab member has one or more training courses overdue. The notice will provide the name of the lab member who is delinquent. This lab member may not access the lab until the training is completed.

C. Visitors conducting research

Drexel benefits from the presence of many visitors and volunteers who come to the University for limited periods of time to participate in its research programs. These individuals may be given either salaried or non-salaried appointments for their research activities. Others wish to use the facilities of the University to engage in their own research or learn new research techniques. These individuals do not hold University appointments, do not provide services to the University, and may not receive compensation. They are instead designated as visiting scholars or visiting scientists. In addition, individuals who are members of the University community as students or employees may provide uncompensated volunteer services in research-related activities that are not part of their course of study or position at the University.

A "visitor" is considered any person who enters a laboratory, clinic area, animal facility, or other potentially hazardous area upon the express or implied invitation of the site's director/supervisor. A "volunteer" is considered any person who, by his/her own decision, provides services to Drexel University with no monetary or material compensation. We have an obligation to ensure that the activities of these visitors and volunteers are conducted in a safe manner. These individuals are subject to the same university policies as employees, as well as applicable federal, state, and local laws that may apply to their activities.

Any Principal Investigator sponsoring visitors or volunteers under the age of 18 that are not currently matriculating at the university must adhere to the below requirements as well as the Minors in Research Laboratories requirements.

There are several restrictions and approvals necessary for visitors and volunteers performing various types of work. The following restrictions and approvals are required where applicable:

- Submit the **Visitor in Research Laboratories Request Form** to **EHRS** for review.
- Complete all required forms as detailed on the **HR Volunteer/Unpaid Intern** webpage. Contact your **HR Partner** for assistance.
- Obtain a Drexel email address if the visitor will be working in the laboratory for longer than six (6) months. A temporary access account will only be issued to individuals working in the laboratory for a period less than six (6) months.
- May not work with human subjects without the prior approval of the **University's Institutional Review Board (IRB)**.
- May not work with patient records or protected health information without completing **HIPAA training**.

- May not work with research animals without the prior approval of the **University's Institutional Animal Care and Use Committee (IACUC).**
- May not work with **recombinant DNA** or infectious agents without prior approval from the **University Biosafety Committee** – the individual should be listed as a visitor or volunteer on the protocol submitted by the sponsoring Principal Investigator.

Principal investigators must add all visitors and volunteers to **BioRAFT** as lab members and complete the job activity assessment upon approval. All visitors and volunteers must complete the required online training courses prior to working in any university laboratory. These individuals must also read and comply with the University's **Laboratory Safety Manual** and **Chemical Hygiene Plan**. The Principal Investigator or the visitor's/volunteer's sponsor will be required to provide task-specific training in handling hazardous materials. The sponsor is responsible for assessing the individual's level of competence and providing further training as necessary. All task specific training must be documented and uploaded to **BioRAFT**.

It is the responsibility of any person sponsoring a visitor or volunteer to ensure the individual understands and is compliant with these requirements. It is also the sponsor's responsibility to ensure the laboratory/facility is in full compliance with all applicable university safety policies and procedures. In the event that the visitor/volunteer or the laboratory is not compliant with these requirements, the visitor/volunteer may be removed from the laboratory and no longer granted permission to perform research activities in a Drexel University laboratory. You may contact the **Office of Research & Innovation** with any questions or concerns regarding the visitor/volunteer requirements.

D. Minors conducting research

If the volunteer is a minor, all proposed activities conducted by minors in University laboratories must adhere to any requirements or restrictions imposed by the University Minor Coordinator, EHRS, the department or school (e.g. HIPAA training for School of Medicine activities), the cognizant Deans, and where appropriate other bodies such as the IRB, University Biosafety Committee, Radiation safety Committee and IACUC. Minors are not allowed to perform high risk experiments. In addition, all required training must be completed by the student prior to engaging in lab activities. The activities must be conducted under an appropriate supervisory plan developed by the faculty member. The Minor in Research Laboratories request form must be completed by the PI and submitted to EHRS for approval. For additional information contact the Department of Environmental Health and Radiation Safety.

E. Biosafety Level 3 Training

Site specific training is required for all laboratory personnel whose work assignments require the use of the BSL-3 facility. A biosafety level 3 facility is equipped to work with small quantities of infectious agents for which a vaccine may not be available. The facility is prefaced by an anteroom, is equipped with a pass-through autoclave, has a collection basin for all drains and has specifically designated ventilation and filtration systems. The training must be completed prior to entering the BSL-3 facility and annually thereafter. The PI is responsible to provide the site-specific training.

F. Refresher training

Refresher training is required for all laboratory researchers, graduate students and principal investigators (PI's) at least annually. Departmental LSLs are responsible for coordinating and tracking updated training. Often, LSLs may arrange for departmental-wide update-training sessions, focusing on results of laboratory audits, and highlight issues that may need improvement. LSLs may invite EHRS to supplement these

training sessions. Individual PI's may conduct research-group-specific safety reviews to supplement or even stand in place of departmental update sessions. Documentation of all safety training must be maintained and upload to BioRAFT using the Document's tab on the PIs profile page.

VII. Laboratory Specific Standard Operating

Standard Operating Procedures (SOPs) are written instructions that detail the steps that will be performed during a given experimental procedure and include information about potential hazards and how these hazards will be mitigated. SOPs should be written by laboratory personnel who are most knowledgeable and involved with the experimental process. The development and implementation of SOPs is a core component of promoting a strong safety culture in the laboratory and helps ensure a safe work environment. PIs/LSL is required to develop and implement laboratory-specific SOPs for certain process that involve hazardous chemicals and "particularly hazardous substances". The SOP must include a Process Risk Assessment to determine the level of risk associated with the specific experiment or process. The assessment evaluates the hazards associated with each task and corresponding safety controls to assist in determining whether the risk is acceptable.

The SOPs must be submitted and reviewed by the EHRS prior to implementation. For certain hazardous chemicals and hazardous substances, or specialized practices, consideration must be given to whether additional consultation with safety professionals is warranted or required. Circumstances requiring prior approval from the PI/LSL must also be addressed in laboratory-specific SOPs. SOPs must be upload to BioRAFT using the Document's tab on the PIs profile page. Contact EHRS to obtain a SOP template.

EHRS created Chemical Safety Summaries (CSS) for over 250 chemicals used at the university. The summary provides the following information on the specific chemicals.

- Chemical Name
- Hazard Rating
- Hazards
- Label Requirements
- Permissible Exposure Limits
- Personal protection equipment required.
- Precautionary Statements

Principal Investigators, supervisors, and laboratory safety liaisons should utilize the summaries to complete the required standard operating procedure and risk assessment for every process in the laboratory. The summaries can be downloaded from the EHRS Website.

VIII. Laboratory Safety Inspections

EHRS has instituted a laboratory safety inspection program for all laboratories in the science, engineering and technology areas. Laboratories are currently inspected on a biannual basis by EHRS to ensure compliance with federal, state and university requirements. EHRS conduct inspections, issue reports, conduct re-inspections when deficiencies are noted, and provide training and coaching on safety and compliance in laboratories. Strong compliance is a critical part of an effective safety program.

The Laboratory Safety Technician will send the laboratories the proposed schedule for inspections. The laboratory may specify a date and time for the inspection to ensure someone is available to present during

the inspection. EHRS strongly recommends scheduling a date and time with the Laboratory Safety Technician.

Inspection reports will be sent electronically through the BioRAFT Compliance Platform. PIs can comment on each finding and receive responses concerning the finding from EHRS. All the comments and responses are recorded in the platform. The platform allows the PI to review the compliance level of his or her laboratory.

Follow-up inspections are performed when the PI or LSL indicates all findings are corrected in the compliance platform or when the findings are overdue.

In addition to the scheduled biannual inspections, EHRS conducts spot inspections throughout the year to ensure the PIs are maintaining compliance with federal, state and university requirements. These spot inspections are unannounced. The report will be sent through BioRAFT Compliance Platform.

The finding due dates are determined by the severity level. Findings noted during an inspection are classified using a 4-point severity scale, with Level 4 indicating the greatest severity. The severity levels are included with the description of any finding during the inspection.

A. Severity Level 1 – Notice

- Situation is a minor departure from Standard Operating Procedures (SOPs), common sense, best practices and/or housekeeping standards.
- Action – All findings will be noted on the inspection. The supervisor must address the inspection findings and update the inspection platform within thirty (30) days. Failure to address the findings within the thirty (30) day period will result in laboratory closure.

B. Severity Level 2 – Moderate

- Situation is not life threatening and does not pose risk of serious illness or injury, and/or significant damage to property. The violation may also be an infraction of EPA, OSHA, and/or local (state, city, institutional) regulations.
- Action – All findings will be noted on the inspection. The supervisor must address the inspection findings and update the inspection platform within fifteen (15) days. Failure to address the findings within the fifteen (15) day period will result in laboratory closure.

C. Severity Level 3 – Important

- Situation is potentially life threatening, with an associated danger that may pose a risk of serious illness or injury, and/or significant damage to property. The violation may also be an infraction of EPA, OSHA and/or local (state, city, institutional) regulations.
- Action – Operations may be discontinued and the occupants evacuated from the room until the situation is resolved. All findings will be noted on the inspection. The supervisor must address the inspection findings inside the laboratory within five (5) days and update the inspection platform within ten (10) days. Failure to address the findings within the five (5) day period will result in laboratory closure.

D. Severity Level 4 – Critical

- Situation is life threatening with an imminent danger that poses an immediate risk of serious illness or injury, and/or significant damage to property.
- Action - Operations will be discontinued and the occupants evacuated from the room until the situation is resolved. All findings will be noted on the inspections. The supervisor must immediately address the inspection findings and update the inspection platform within five (5) days. The laboratory will remain closed until all findings are addressed.

E. Repeat Finding

EHRS will send a closure notice to the PI if any laboratory has a finding that is recorded three (3) or more times in 18 months. The closure notice will include the finding and a deadline to address. The deadline will be no longer than 24 for hours. The laboratory will be closed if the finding is not addressed prior to the deadline. The laboratory will remain closed until the finding is addressed.

IX. Laboratory Decommissioning and Relocation

The EHRS will assist in the decommissioning or relocation of laboratories on campus in order to minimize hazards to university employees, to maintain compliance with all applicable federal, state and local regulations, and to promote environmental stewardship. The decommissioning and relocation program applies to all University laboratories and any auxiliary support areas. The program includes the requirements for the removal of all chemical, physical, biological, and radiological hazards associated with research from the aforementioned spaces when the area is being vacated for any of the following reasons:

- The Principal Investigator is leaving the University
- The Principal Investigator is relocating to a new laboratory within the University
- The Principal Investigator is relocating to an off-campus location
- The space is being vacated for renovations
- The space is scheduled for demolition.

The Units' head or chair or the principal investigator(s) are responsible for notifying EHRS thirty (30) days before vacating the space. A current chemical inventory must be submitted to EHRS along with the notice of intent to vacate. EHRS will conduct a pre-inspection of the space with the Principal Investigator to identify all chemical, physical, biological and radiological hazards within the space. If a vacated laboratory or auxiliary laboratory support area is being occupied by a new Principal Investigator, it is the responsibility of the new Principal Investigator to ensure the space is free of recognized hazards prior to occupying the space. EHRS should be contacted for assistance.

X. Medical Surveillance

A laboratory worker shall be required to obtain medical consultation and examination under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- Where exposure monitoring reveals an exposure level above the OSHA Action Level (AL), Permissible Exposure Limit (PEL) or Short-term Exposure Limit (STEL).

- When 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.
- When working with certain biological, chemical, and physical agents including employees who work with patients, laboratory animals, bloodborne pathogens, other infectious agents, formaldehyde, xylene, class 3b or 4 lasers, and/or those whose work requires the use of a respirator.
- Whenever an individual's immune status may have changed, such as in the event of a change in personal health status, or pregnancy.

Medical consultations are provided through the university occupational health care provider. Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. An attending physician will decide if the employee needs to be referred for further treatment. If there is a medical emergency, personnel should go immediately to the Emergency Room (ER) and call the Drexel's Public Safety Office at (215) 895-2222, if assistance is needed.

In the event of an incident, PIs, Lab Safety Liaisons and/or Supervisors shall collect as much information as possible about the person, the substances involved, SDS, symptoms, and any other relevant data, to provide to the attending physician. The physician in charge will inform the employee about the medical examination results, related conditions, tests required, and whether any follow-up is required.

The occupational health provider shall keep written records of all such medical examinations and must maintain these records for the duration of employment plus 30 years. Such records shall contain, but are not limited to, physicians' opinions, recommendations, results of any tests performed, and any follow-up actions. Upon written request by the employee or an authorized representative, the employer shall make such records available for review.

XI. General Laboratory Safety

A. Introduction

This Laboratory Safety Manual offers generic safety procedures and standard operating procedures for laboratories on Drexel University campuses. Please note that this document contains a minimum set of procedures, regulations, and recommendations required to maintain a safe working environment. The manual does not provide laboratory workers, students, research students, or teaching assistants with specific standard operating procedures (SOP) necessary to work in their respective laboratories. It is the responsibility of the Principal Investigator to develop specific standard operating procedures for his/her laboratory. The SOPs must identify the hazards of the protocol, as well as measures to be taken to mitigate those hazards. Standard operating procedures must be readily available to all laboratory employees, students and visitors. It is the responsibility of each person that enters the laboratory to understand the safety and health hazards associated with potential hazardous materials and equipment in the laboratory. It is also the individual's responsibility to practice and follow general safety procedures.

B. Twenty-One Basic Rules for Prudent Safety Practices

1. Attend / complete all required laboratory safety training prior to the start of your research assignment.
2. Read all procedures and associated safety information prior to the start of an experiment.
3. Always wear proper eye protection in laboratories and areas where hazardous materials are handled and/or stored. Appropriate eye protection consists of safety glasses with side shields, goggles, or face shields.

4. Always know the hazards associated with the materials that are being utilized in the laboratory.
5. Always wear appropriate personal attire and protective clothing in laboratories and areas where hazardous materials are handled and/or stored. Clothing must come down to the ankle and cover all exposed skin. Shorts, short skirts and other clothing that leave sufficient skin exposed must not be worn in the laboratory without appropriate protective clothing. Cover areas of exposed skin with a lab coat, coverall, or apron.
6. Confine long hair and loose clothing.
7. Always wear appropriate footwear that completely covers the foot in laboratories and areas where hazardous materials are handled and/or stored. Do not wear high-heeled shoes, open-toed shoes, sandals, flip-flops, perforated shoes, any shoes made of canvas or woven material or any other open top shoes.
8. Always wash hands and arms with soap and water before leaving the work area. This applies even if you have been wearing gloves.
9. Never perform any hazardous work when alone in the laboratory. At least two people shall be present. Undergraduate students must be supervised at all times by a TA, Instructor, Principal Investigator, Supervisor or other experienced laboratory personnel.
10. Never perform unauthorized work, preparations or experiments.
11. Never engage in horseplay, pranks or other acts of mischief in laboratories and areas where hazardous materials are handled and/or stored.
12. Never remove chemicals, biological agents, or radioactive materials from the facility without proper authorization.
13. Familiarize with the location of emergency equipment - fire alarm, fire extinguisher, emergency eyewash and safety shower. Know the appropriate emergency response procedures.
14. Use equipment and hazardous materials only for their intended purposes and with sufficient training.
15. Never mouth pipet when transferring solutions. Instead, you should always use a pipet bulb or other pipetting devices to transfer solutions.
16. When using hazardous materials use a chemical fume hood, glove box or biosafety cabinet, as directed by your supervisor, instructor, or principal investigator.
17. Never eat food, drink beverages, chew gum, apply cosmetics (including lip balm), or handle contact lenses in the laboratory.
18. Report to your supervisor any accident, injury, or uncontrolled release of potentially hazardous materials - no matter how trivial the accident, injury, or release may appear.
19. Seek immediate assistance if you are splashed by any of the hazardous materials, use running water from an eyewash station or emergency shower for at least 15 minutes or until emergency assistance arrives and provides you with different instructions.
20. Do not leave active experiments unattended. Never leave anything that is being heated or is visibly reacting unattended.
21. Properly segregate chemicals into compatible categories and properly dispose of all laboratory waste in accordance with the University's Hazardous Waste Management Plan.

C. Housekeeping

Keeping laboratories clean and organized helps provide a safer laboratory. The following items are steps to take to ensure the upkeep of a laboratory.

- Keep all work areas clean and free of clutter. Clean up the work area on completion of an operation or at the end of each work shift or class.
- Absorbent pads should be discarded and counter tops wiped down at least once a day.
- Keep drawers and cabinet doors closed and electrical cords off the floor to avoid tripping hazards.

- Keep aisles clear of obstacles such as boxes, chemical containers, and other storage items that might be put there even temporarily.
- Avoid slipping hazards by cleaning up spilled liquids promptly and keeping the floor free of stirring rods, glass beads, stoppers, and other such items.
- Never block or even partially block the path to an exit or to safety equipment such as a fire extinguishers, safety showers or eyewash stations.
- Make sure that supplies and equipment on shelves provide sufficient clearance so that fire sprinkler heads operate correctly. There shall not be any storage within 18 inches of a sprinkler head.
- Put ordinary wastepaper in regular trash.
- Broken glass shall be disposed in the approved sharp containers. See section on Broken Glass Disposal.

D. Personal Protection Equipment

OSHA's new final standard on personal protection equipment, 29CFR 1910 132, Subpart I, imposes several new and important requirements relating to basic safety and health programs. The standard adds new general requirements for the selection and use of personal protection equipment (PPE).

A variety of laboratory personal protection equipment is commercially available and commonly used in laboratories. However, for the equipment to perform the desired function it must be used and managed properly. Principal Investigators and/or Laboratory supervisors must conduct a risk assessment to determine the need for such equipment, monitor its effectiveness, train the employees, and monitor and enforce the proper use of such equipment.

When selecting PPE, consider three key things:

- First is the type of anticipated exposure, which is determined by the potential for exposure by such factors as absorption, inhalation, injection or ingestion. PPE selection, particularly the combination of PPE, also is determined by the category of hazard exposure and handling.
- Second, and very much linked to the first, is the durability and appropriateness of the PPE for the task. This will affect, for example, whether a gown or apron is selected for PPE, or, if a gown is selected, whether it needs to be fluid resistant, fluid proof, or neither.
- Third is fit. PPE must fit the individual user and ensure that all PPE are available in sizes appropriate for the workforce that must be protected.

There are three key rules to remember when using PPE:

- Don PPE before you have any contact with the hazardous materials.
- Remove the PPE carefully when you have completed your tasks. Disposable contaminated PPE shall be discarded in the appropriate hazardous waste container. Non-Disposable contaminated PPE shall remain in the contaminated area.
- Immediately perform hand hygiene before going on to your routine needs.

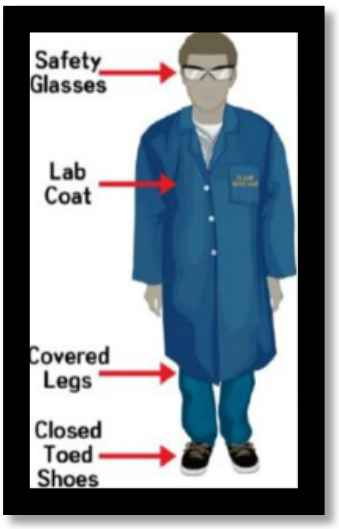
1. Required Personal Protection Equipment and Personal Attire for Laboratory Access

All laboratory personnel and visitors must wear the required PPE. You will be removed from the laboratory if you are not wearing the required PPE. Laboratories that continually disregard the required PPE may be closed for a time period determined by EHRS.

a. Eye Protection

Appropriate eye protection is worn at all times by all persons in laboratory. Eye protection consists of safety glasses with side shields, splash goggles or face shield, or full-face respirator. Chin length face shields are to be worn to prevent splashes or sprays of blood, infectious materials, or hazardous chemicals when there is a potential for eye, nose, or mouth contamination.

Eye protection is required whether or not one is actually performing experimental operations and must be worn by all lab personnel and visitors. Prescription eyeglasses and contact lenses are not appropriate protection.



Laboratory personnel may remove the eye protection if work involves viewing samples or specimens through a microscope.

b. Body Protection

Appropriate body protection is worn at all times by all persons in the laboratory. Body protection consists of a laboratory coat, pants, shirt, and closed top/toed shoes. Clothing that exposes large areas of skin is not permitted. Shorts, skirts, and short pants that expose large areas of skin are prohibited from being worn in the laboratory. Open top/toed shoes, flip flops, perforated shoes, sandals, and cloth shoes do not provide protection from hazardous materials and are prohibited from being worn in the laboratory. Shoes must cover the entire foot.
Personnel working with flammable, pyrophoric or reactive chemicals must wear flame-resistant laboratory coats (e.g. Nomex®). Laboratory coats must not be worn in the hallways or common spaces outside the lab.

2. Other Personal Protective Equipment

a. Gloves

Laboratory personnel are required to wear appropriate gloves when there is a potential for direct contact with blood, hazardous chemicals, infectious agents, or other hazardous materials.

Select gloves appropriate for the task. Gloves protect differently for each chemical. Wearing the wrong type of glove can be more hazardous than wearing no gloves at all. If the chemical seeps through, the glove can hold it in prolonged contact with the wearer's skin. For more information concerning glove selection contact EHRS. The EHRS website has a link to the AnsellGuardian glove selection chart. This can be used to identify the appropriate gloves for the task.

- Use disposable gloves when dexterity is needed and the contamination warrants one time use.

- Use heavy duty gloves when the hazard requires it. For example, use butyl gloves (picture to the right) to handle 70% nitric acid. The permeation breakthrough time for this butyl glove is greater than 480 minutes.
- Use puncture or cut resistant gloves when handling sharp objects.
- Use insulated gloves when handling cryogenic or hot materials.
- Wash hands prior to wearing gloves.
- Double glove to provide multiple lines of defense when working with highly toxic or multiple hazard materials.
- Inspect and change gloves frequently to avoid exposure. Wash hands with soap and water immediately after removing gloves.

Gloves must only be worn in the lab and taken off before leaving, especially when handling infectious material. If transporting hazardous materials from one are to another, glove one hand to hold the product/apparatus or push the cart and use a clean, ungloved hand to open doors, press buttons, etc.

b. Respiratory Protection

Use appropriate respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls. The Principal Investigator must perform a risk assessment to determine the need for respiratory protection. Assistance with this assessment can be obtained by contacting EHRS at ehrs@drexel.edu.

The odor threshold for many chemicals is much lower than the permissible exposure limit, and in many circumstances, is a great indicator of exposure. Refer to the Odor Threshold Chart below and the OSHA PEL list to determine if a respirator is required.

Odor As An Aid to Chemical Safety		
Chemical	**Threshold Limit Value (Parts Per Million)**	**Air Odor Threshold (Parts Per Million)**
Acetone	750	13
Ammonia	25	5.2
Arsine	0.05	0.5
Carbon Monoxide	50	100,000
Chlorine	1	0.31
Chloroform	10	85
P-Dichlorobenzene	75	0.18
Ethyl Alcohol	1000	84
Ethyl Ether	400	8.9
Hydrogen Sulfide	10	0.008
Methyl Alcohol	200	100
Methylene Chloride	100	250
Naphthalene	10	0.084
Ozone	0.1	0.045
Phenol	5	0.04
Toluene	100	2.9
Vinyl Chloride	5	3000
M-Xylene	100	1.1

**Extracted from the Journal of Applied Toxicology. Vol3(6), 1983*

When the use of respirators, in research laboratories, is necessary to maintain exposure below the permissible exposure limit (PEL), the respirator will be provided by the PI at no cost to the employee. EHRS will provide students, at no cost, with respirators when the use is necessary to maintain exposure below the permissible exposure limit (PEL).

The proper respiratory equipment can be obtained contacting EHRS at ehrs@drexel.edu. The respirators shall be selected and used in accordance with the requirement of 29 CFR 1910.134 and ANSI Z88.2-1969. Training, an annual physical and pulmonary function test will be required for all individuals requiring the use of respirators in accordance with OSHA's standards on respiratory protection 29 CFR 1910.134. Proper respiratory equipment includes the following types:

- Air Purifying Respirators (APR)
    - Tight fitting dust/mist - N95, R95, P95, N100, R100, P100
    - Tight fitting Half-Faced
    - Tight fitting Full-Faced
    - Powered Air Purifying Respirator (PAPR)
- Supplied Air Respirators (SAR)
    - Self-Contained Breathing Apparatus (SCBA)

The requirements set forth in the University's Respirator Protection Policy must be fulfilled prior to performing work with a respirator. Contact EHRS at safeheal@drexel.edu to enroll in the program. Do not got to the local hardware store to purchase a respirator for use. You may purchase a respirator that is inappropriate for the hazard.

c. Hearing Protection

The Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.95 provides the mandatory guidelines for developing a Hearing Conservation Program. Employees who are routinely exposed to noise levels exceeding 85 dBA during an 8-hour time-weighted average (TWA) shall be included in the Hearing Conservation Program. Aspects of the program include:

- Evaluation of noise exposures;
- Initial and annual audiometric testing;
- Provision of hearing protection devices;
- Initial and annual training;
- Recordkeeping.

If employees are exposed over 90 dBA averaged over an eight-hour period, the following aspects of the Hearing Conservation Program shall also apply:

- EHRS shall assess whether noise exposures can be reduced below 90 dBA TWA using engineering or administrative controls; and
- Hearing protection for laboratory personnel is mandatory if noise levels can't be reduced below 90 dBA.

Hearing protection is the most common method for reducing noise exposure in the workplace and shall be made available to all lab personnel exposed at or above the action level (AL) or permissible Exposure Limit

(PEL), for those who have incurred a STS (Standard Threshold Shift), or who have been exposed in excess of six months without having had a baseline audiogram. Hearing protection should meet the following criteria:

- Capable of reducing exposure to 90dBA, or to 85 dBA for those exhibiting a STS.
- Supplied to employees at no cost and replaced as necessary. The principal investigator must supply students with hearing protection at no cost.
- Chosen based on its attenuation for the specific noise environment in which it will be used; however, the hearing protector of choice must attenuate the noise below 85 dBA. Contact EHRS at ehrs@drexel.edu to determine the appropriate hearing protection.
- Available at the entrances posted as high noise level areas.

E. Eating, Drinking and Using Cosmetics

The first rule of laboratory safety in the lab is not to put any chemicals into your mouth or eyes. Although this sounds like a really simple common-sense rule, many workers and students in the laboratory do not realize that eating, drinking or applying makeup in the laboratory can be a danger. Chemicals in the air, on the lab bench or on your hands can easily be transferred to food, drink or makeup. If you must eat or drink while working, leave your food or beverage in a place outside of the laboratory, and wash your hands before stepping outside to eat or take a drink. Do not store food or drinks in a refrigerator that contain chemicals, biological materials or radioactive materials. Post a sign on the refrigerator door "NO FOOD OR DRINK TO BE STORED IN THIS REFRIGERATOR".

F. Pipetting

Mouth pipetting is forbidden. There are many alternatives to mouth pipetting such as use of pipet bulbs, use of mechanical or electrical pipetting devices. Pipetting in some cases is a repetitive task that may result in injuries especially when pipetting for extended periods. Studies have found that there is a significant increase in the risk of hand and shoulder discomfort when laboratory workers pipet for more than 300 hours per year. That is the equivalent of 1 hour and 15 min per day for a 50-week work year. Many lab workers pipette for longer periods each day. Typical symptoms include pain in the thumb (De Quervain's syndrome), forearm and elbow (tendonitis or tenosynovitis), trigger finger, finger pain (digital-nerve injury), and shoulder pain.

There are many steps that can be taken to prevent the onset of repetitive-strain injuries associated with pipetting.

1. Work Technique and Habits

- Keep your neck in a neutral position and avoid jutting your chin forward or bending your neck down when pipetting. Adjust the height of the chair so that you do not need to strain.
- Sit back in the seat to keep your back supported. If you sit back and your feet no longer reach the ring or the floor, adjust the ring or get a footstool.
- If your stool lacks back support, you can tilt the seat forward or use a seat wedge to position the back and the pelvis in a better position.
- Maintain neutral arm postures as much as possible. Keep the elbows close by the side of your body. To achieve this position, sit close to your workbench, hold objects close to the body, and adjust your chair up or down to the proper height of the bench.

- Keep your wrist in a neutral or straight position as if you are shaking hands when pipetting. Do not twist or rotate the wrist. Alternate hands if possible or use both hands to operate the pipette.
- Use as little pressure as possible when pipetting. Try to press the plunger with as light a touch as possible. Use a light touch to get pipette tips on the pipette. Do not use excessive force when changing tips. Tip ejectors can require large forces to operate. Newer models are available with low force levels.
- Drop pipette tips into a low approved sharps container; try not to have to reach up if you do not have to. Make sure that the trigger mechanisms on the pipette require low force levels to activate
- Alternate the position of objects held in your hand. Alternating between the thumb and the first finger and the first and second fingers will vary the task. Even when alternating, don't forget to take breaks every 20 minutes to allow muscles to rest and the blood to flow back into your fingers.
- Avoid long sessions of repetitive motion by varying your activities. Rotate pipetting tasks with your co-workers.
- Change your position and work task frequently. For example, take a two-minute break for every 20 minutes of pipetting.

2. Work tools/Equipment

a. Use an electronic pipetter when possible. Always select a pipetter that is a comfortable size and weight for your hand.
b. Use a latch-mode for repetitive pipetting tasks.
c. Exchange traditional pipets for light touch models.
d. Use pipettes that use the pointer finger to aspirate and the thumb to dispense.
e. Select a pipetter with an aspiration rate control that will allow you to select the speed of pipetting so that you can maintain a reasonable pace.
f. Use thin-wall pipette tips that fit correctly and are easy to eject.
g. Clean pipetters on a scheduled basis.
h. Use gloves that fit properly. Gloves that are too big or small cause undue stress.
i. Wear supportive shoes and stand on cushioned mats if you must stand for prolonged periods when pipetting.
j. Use padding or larger buttons when possible, to reduce pressure on your body. Pad equipment to increase ease of gripping. Elbow pads can be worn to reduce pressure on the arms while working at a bench. Apply padding to the edge of the work surface to avoid resting your elbows on hard or sharp edges.

3. Work Environment

a. Always work at a cutout in the lab bench. This will allow you to work as close to the bench as possible while sitting against the back of your chair.
b. Keep trays and other supplies that are used frequently in close reach.
c. Adjust the workstation or your chair so that you do not have to work with your arm in an elevated position. Try to keep your work at waist level.
d. If using a computer at the same time as pipetting, be sure to position yourself correctly at the computer. Your computer keyboard should be placed on an adjustable height and angle keyboard tray. You may have to remove unused cabinets or drawers beneath the countertop to install a keyboard tray. Sit all the way back in the chair; use the tray to lower the keyboard and mouse and position the elbows and wrists in a neutral position; and place the monitor in front of you and at a level where the eyes gaze slightly downward.
e. Always try to plan ahead. Think about how your work tasks affect your body mechanics and adjust accordingly.
f. UCLA safe pipetting technique video.

G. Syringes and Needles

The hypodermic needle is a dangerous instrument. To lessen the chance of accidental injection, aerosol generation, or spills, the use of syringes should be avoided when alternate methods are available.

- When working with hazardous material, use the syringe and needle in a biological safety cabinet, chemical fume hood, or glove box and avoid quick and unnecessary movements of the hand holding the syringe.
- **Re-capping** the needle is strictly prohibited. Dispose all contaminated needles in an approved sharps container.
- Place the needle-syringe in a tray or other protective container for transportation or storage between injections.
- Needles **must not** be bent, sheared broken, recapped, removed from disposable syringes or otherwise manipulated before use.
- Examine glass syringes for chips and cracks, and needles for barbs and plugs. This should be done prior to sterilization before use.
- Use needle-locking syringes only and be sure that the needle is locked securely into the barrel. Replace glass syringes with plastic disposable syringes whenever possible.
- Whenever possible use safer needle systems.
- Wear personal protection equipment for all manipulations with needles and syringes.
- When working with infectious materials refer to the University's Bloodborne Pathogen Exposure Control Plan.
- Discard syringes into a sharps container. DO NOT bend, shear, recap or otherwise manipulate the needle.

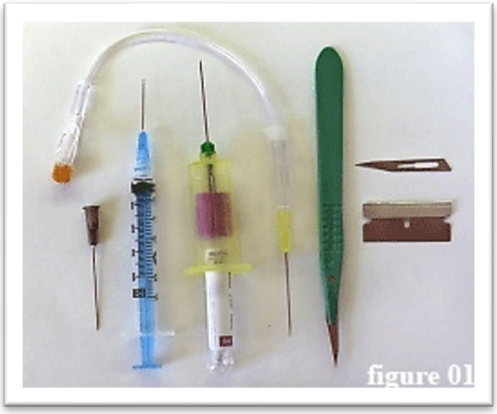


figure 01

Additional information concerning syringe and needle safety can be found in the University's Bloodborne Pathogen Exposure Control Plan.

H. Sharps, Glass and Pasteur Pipettes

1. Sharps

Sharps are ***those instruments when intact or broken have the ability to, cut, scratch or pierce the skin or breach mucus*** membranes. Used or infectious sharps are sharps that have been in contact with infectious agents or that have been used in animal or human patient care or treatment. Sharps used or not must be handled with special precautions and disposed in an approved sharps container. Sharps containers must be rigid, tightly lidded and puncture resistant. Disposal of sharps in non-approved waste containers or in the regular trash creates a serious hazard to housekeeping employees. Laboratory personnel must never remove any item placed in the sharps container.

The sharps definition includes, but is not limited to, the following "SHARPS" items.

- Hypodermic needles
- Syringes (plastic, glass or metal) to which a needle can be attached, with or without the needle
- Broken glass that has been in contact with pathogenic organisms
- Broken or unbroken glass or rigid plastic ware

- Needles with attached tubing
- Suture needles
- Lancets
- Scalpel blades
- Blood vials
- Glass or plastic Pasteur pipettes
- Glass capillary tubes
- Microtome blades
- Dental scalers
- Razor blades
- Culture dish
- Slides
- Cover slips
- Sharp metal
- Wood-stemmed cotton swabs and applicator sticks
- Pipette tips
- Centrifuge tubes

For additional information on sharps, please refer to the University's Bloodborne Pathogen Exposure Control Plan.

2. Laboratory Glass

Uncontaminated, non-sharp and unbroken "Laboratory Glass" is considered Sharps waste and must be disposed in an approved Sharps container. Laboratory glassware and plastic ware is any item that could puncture regular trash bags and potentially cause injury to someone. Use tongs, dustpan and broom or heavy gloves when handling and disposing broken glassware.

Following procedures are to be followed for disposing nonhazardous or non-infectious glassware.

- Place broken and unbroken glassware in an approved Sharps container.
- Place broken and unbroken rigid plastic ware in an approved Sharps container.
- Chemical bottles must triple rinsed. The labels defaced prior to placing in the approved Sharps container.
- DO NOT place glassware in regular waste containers.
- Do not contaminate the container with hazardous or radioactive waste.
- Once the container is 3/4th full, close the lid of the sharps container.
- Leave Sharps container in the laboratory for removal by the University's vendor.
- Contact the Department of Environmental Health and Radiation Safety to request sharp containers. EHRS will provide a 17-gallon reusable container for disposal of sharps.

3. Plastic Pipette Tips

Uncontaminated plastic pipette tips are considered sharps waste because they have the potential to puncture or cut housekeeping personnel. The tips must be disposed in an approved sharps container.

I. Compressed Gas Cylinders

1. Labeling

- All compressed gas cylinders are required to be clearly labeled as to the contents and any associated hazards. Deteriorated or corroded labels must be replaced.
- All cylinders without adequate labeling to identify contents shall be labeled as "Contents Unknown" and returned to supplier. Color coding is not a reliable method of determining contents.
- Tags marked full, in service or empty will be placed on cylinders. The gas delivery vendor is required to indicate the department the cylinder belongs too.

2. General Handling and Storage Procedures

- Compressed gas cylinders shall be transported on chain equipped hand trucks or carts. Never roll or drag cylinders. This process can damage the cylinder and can possibly cause injury.
- All compressed gas cylinders, empty or full, must be secured individually in the upright position by using an approved single chain or, strap 2/3 of the way up from the floor, to a stationary building support (wall or floor), or to a cylinder cart or stand to prevent falling.
- In circumstances where more than one cylinder needs to be secured with a single chain/strap, no more than six (6) cylinders can be stored with one chain/strap in that event.
- Lecture bottles must be placed in a rack designed for the purpose (resembling an oversize test-tube rack) or be firmly clamped to a ring stand with a heavy base, in an upright position.
- Cylinders shall never be dropped or permitted to strike each other violently.
- Valve safety covers shall be in place until pressure regulators or needle valves are ready to be attached.
- Employees must not attempt to repair cylinders or cylinder valves, or to force stuck or frozen cylinder valves.
- Cylinders not required for current use shall remain in the laboratory at all times unless approved by EHRS or be stored in the loading dock gas cylinder cage if available. If stored indoors, cylinders should be stored in well-ventilated areas away from sources of heat and ignition. The area must be secured from unauthorized access with appropriate signage on the outside to inform emergency personnel of potential hazards.
- When stored in the open, cylinders must be protected from direct sunlight.
- Cylinders shall not be stored near corrosive chemicals or fumes.
- Oxygen cylinders and cylinders containing oxidizing gases, such as nitrous oxide, must not be stored within 20 feet of those containing any flammable or highly combustible gas unless the cylinders are separated by a five (5) foot high thirty (30) minute fire wall.
- Flammable gases, whether empty or full, must not be located near an exit or any location which could block and exit in the event of a release or fire.
- Cylinders must not be lifted by machinery unless they are on a safe stand or cradle or are otherwise positively secured against falling or being dropped.
- Special arrangements should be made to secure cylinders while they are being transported. Carrying them loosely on the back of a truck or in a pickup is prohibited. Facilities Management is not permitted to move or transport any gas cylinders.
- Do not store or transport acetylene cylinders on their side, as this causes the acetylene to become less stable and unsafe.
- Close the cylinder valve when the equipment is not in use or unattended overnight.
- Automatic pressure regulators or reducing valves shall be used on all gas cylinders to maintain a uniform gas supply at the correct pressure.

- Only regulators listed by agencies such as Underwriters Laboratories® or Factory Mutual should be used. Use only the appropriate, designated regulator for the specific gas to be used.
- Do not use oil around oxygen gauges, valves or connectors. Follow supplier's recommendations for cleaning of the cylinder outlet fittings and openings.
- When not in use, the regulators must be removed, and the gas cylinder must be properly capped.
- Cylinders containing toxic, highly toxic or flammable gases must be stored in an approved storage areas in accordance with the Philadelphia Fire Code. The use of the smallest possible cylinder of toxic or flammable gases is recommended. Toxic, highly toxic, and flammable gas use requires vented gas cabinet and leak detection equipment. All work involving these materials require EHRS approval.
- Gas mixtures that contain >5.5% hydrogen in nitrogen, >2.94% hydrogen in argon, and >3.9% hydrogen in helium are classified as flammable gases. These gas mixtures must be stored and used in a vented gas cabinet with hydrogen detection.
- Smoking or flame is prohibited near oxygen or flammable gas cylinders or outlets.
- Storage areas for compressed gas cylinders, especially flammable gases, must be free of any unnecessary combustible materials or uncontrolled ignition sources.
- Handle and store containers of cryogenic liquid cylinders in an upright position. The containers shall not be dropped, tipped over, or rolled on their sides. Use a four-wheeled hand truck designed to move such containers to move cryogenic liquefied gas containers with a capacity greater than 20 gallons.
- Store and handle cryogenic liquefied gas containers in well-ventilated areas to prevent hazardous concentration of the gas. Cryogenic liquefied gas containers have a tendency to release pressure due to over pressurization.

3. Handling and Storage of Cylinders without Regulators

- The valve safety covers must be left on the cylinders at all times when not in use.
- Cylinders must be transferred only by approved carts or hand trucks. They must not be rolled on their sides or dragged.
- The valve safety covers must be in place and the cylinders secured to the carts during transport.

4. Acceptance of Cylinders from Vendors

- The contents of cylinders must be identified with decals, stencils, or other markings on the cylinders. Color codes alone or tags hung around the necks of the cylinders are not acceptable. Cylinders lacking proper identification must not be accepted from the vendors.
- Gas delivery vendors are not permitted to leave gas cylinders unsecure in the hallways of any building. The vendor has been instructed to return the cylinder if the responsible party is not available to receive it.
- Cylinders must not be accepted from the vendors unless the valve safety covers are in place and properly tightened.
- Vendors transporting cylinders must use chain equipped hand trucks or carts. Cylinders must not be rolled on their sides or dragged.

5. Empty Cylinders

- A small volume of gas is present in the cylinders even when the regulator reads empty or zero.
- Empty cylinders shall be marked **"EMPTY" or "MT"** as well as the department they come from.
- Valve safety covers and the labels showing contents must be in place.
- Empty cylinders must be secured at all times so they cannot fall.

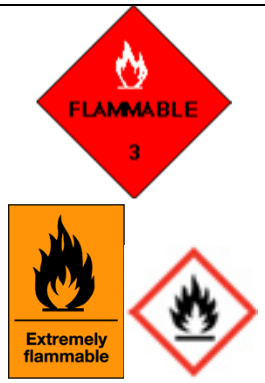
- Personnel shall not remove cylinders which are not appropriately marked, or which do not have protective valve covers in place, and shall report this to EHRS.

J. Hazard Warning

Hazard warning signs are required by several regulatory agencies and advice individuals who work in or may need to enter an unfamiliar laboratory as to the types of hazards that are present. These signs are also required by emergency response personnel such as Drexel's Public Safety, EHRS, and the Philadelphia Fire Department. The exterior surface of laboratory doors must be reserved for hazard communication labels. All laboratories containing hazardous materials must have the appropriate hazard warning posted on the entrance door. All chemical storage areas within the laboratory must be labeled with the appropriate hazard warning such as a symbol or NFPA diamond. Work areas designated for the use of highly hazardous chemicals (such as cadmium or pyrophoric chemicals) must also be appropriately labeled. Storage and work areas for biological and radiological hazards must also be properly labeled. If someone needs to enter a location posted with a hazard sign, consult with either the laboratory personnel or EHRS before entering and make sure the room is secured when you leave.

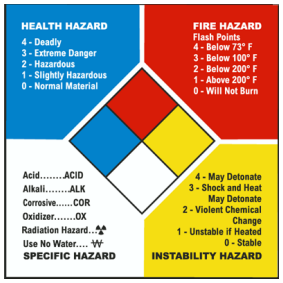
1. Hazard Symbols

Hazard symbols are easily recognizable symbols design to warn about hazardous materials, locations, or objects. The following are typical hazard warning symbols utilized throughout Drexel University.

			
Oxidizer	Biohazard	Health Hazard	Flammable
			
Corrosive	Radioactive	Poison	Irritant

2. National Fire Protection Association Label

National Fire Protection Association (NFPA) hazard identification systems use a color-coded diamond to represent four different types of hazards for chemicals. The different colors represent four different types of hazard:



3. Emergency Contact Information

The door labels **MUST** contain emergency contact information that includes:

- Name and telephone numbers for the faculty and staff responsible for that location.
- After hour contact number. This number cannot be EHS, Public Safety or a departmental administrator. The purpose is to reach someone knowledgeable about the operation.
- The name and telephone number of the Department responsible for the location.

The approved emergency contact label is pictured to the right.


LABORATORY EMERGENCY INFORMATION

Emergency Contact Information

Name Telephone#

1. _____
2. _____
3. _____

After Hour Contact Number _____

Department: _____

Telephone: _____ Date Posted: _____

Hazards contained in laboratory:

(Check all that apply)

____Radioactives	____Explosives
____Flammables	____Poisons
____Oxidizers	____Corrosives
____High Voltage	____LASER
____UV Light	____Biohazards

If you have any questions regarding which type of labels may be required for your laboratory, you may contact EHRS at ehrs@drexel.edu. For additional information on hazard warnings, please refer to the University's Chemical Hygiene Plan.

4. Removing Hazard Labels

Radioactive and biohazard hazard labels can only be removed after appropriate decontamination or sterilization procedures, and the laboratory has been rendered safe for other usage. For assistance on decontamination of radioactive materials contact the Radiation Safety Officer at 215-895-5919. For decontamination and sterilization procedures, for biohazards, contact EHRS at ehrs@drexel.edu.

K. Electrical Safety in the Laboratory

The hazards associated with the use of electricity include electrical shock and electrical fires caused by shorts and overloaded circuits or wiring. In addition, sparks from electrical equipment can serve as an ignition source for flammable or explosive vapors or combustible materials. Most incidents are a result of unsafe work practices, improper equipment use, and faulty equipment. Adherence to the following rules and procedures can significantly reduce the electrical hazards one might encounter in the workplace and ensure compliance with OSHA regulations.

- Know the location of electrical panels and disconnect switches in or near your laboratory so that power can be quickly shut down in the event of a fire or electrical accident. To enhance safety, post the location of the electrical panel on the equipment it services.
- Never obstruct electrical panels and disconnect switches. These should be clearly labeled to indicate what equipment or power source they control. **A minimum 3-foot clearance must be maintained around and above electrical panels at all times to permit ready and safe operation and maintenance of such equipment.**

- **Do not overload circuits or wiring.** Overloading can lead to overheated wires and arcing, which can cause fires and electrical shock injuries.
- Inspect all electrical equipment (hot plates, stirrers, ovens, extension cords, etc.) before use to ensure that cords and plugs are in good condition—not worn, twisted, frayed, abraded, corroded, or with exposed wires or missing ground pins. Live parts must be effectively insulated or physically guarded. Equipment with damaged or defective cords or plugs shall be taken out of service immediately and repaired by qualified personnel.
- Ensure that all electrical outlets have a grounding connection requiring a three-pronged plug. All electrical equipment shall have three-pronged, grounded plugs or be double-insulated.
- Electrical outlets, wiring, and other electrical equipment integral to the building may only be serviced and repaired by Facilities Operations qualified trades personnel or other qualified electricians.
- Work on electrical equipment must be done only after the power has been disconnected and locked/tagged out of service (LOTO). On cord and plug connected equipment, the power cord must be unplugged under the exclusive control of the person performing the work so that the equipment cannot be accidentally turned on by someone else. On hard-wired equipment, the main disconnect device or circuit breaker must be shut off and locked and tagged with a special padlock and tag**. Service and/or repair work on hard-wired equipment may only be carried out by authorized individuals who have received Lockout/Tagout training.** Contact EHRS at ehrs@drexel.edu.
- Limit the use of extension cords—they are for temporary, short-term use only. In all other cases, request the installation of a new electrical outlet. Do not use extension cords as substitution for fixed receptacle outlets. **Long-term use of extension cords is a violation of OSHA regulations.** The long-term use of multi-outlet power strips is also illegal, except for use with computer equipment.
- Ensure that all extension cords used are carefully placed, visible, and not subject to damage. Cords must not run across aisles or corridors where they might be damaged or create a tripping hazard. Cords must not run through doors, walls or partitions, under rugs, or above dropped ceilings. They must not be tied in knots, draped overhead, or attached to walls.
- **Ensure that the wire size of an extension cord is adequate for the current to be carried**. Failure to do so can lead to electrical fires. Cords used for 110-120-volt service should be UL listed with a polarized three prong plug. Extension cords must never be linked together—use the proper length extension cord needed for the application.
- Keep corrosive chemicals and organic solvents away from electrical cords—these can easily erode the insulation on wires.
- Keep flammable materials away from electrical equipment.
- Keep electrical equipment away from wet or damp locations or potential water spillage, unless specifically rated for use under such conditions.
- Never handle electrical equipment when hands, feet, or body are wet or perspiring or when standing on a wet floor.
- Equivalent ordinary household equipment or other items such as vacuum cleaners, drills, rotary saws, or other power equipment are not suitable for use in laboratories where solvents are utilized.
- Devices with resistive heating elements, such as furnaces, heat guns, hot plates, and ovens should be configured in such a way that personnel cannot come into contact with an electrically active element, nor should volatile solvents be used in the proximity of such devices where the temperature may exceed the ignition temperature of the solvent.
- **In the event of an electrical fire, leave the area, call 911, and pull the nearest fire alarm.** Do not use water on an electrical fire. If safe and possible, shut down the main power source.
- In an electrical emergency, if a person received an electrical shock, do not touch the equipment, cord or person. **Call 911 so that the Fire Department can treat the injured person and evaluate the situation.** If safe and possible, shut down the main power source.

L. Hand and Portable Power Tools

Hand and power tools are common in the research and teaching laboratories across the university. Laboratory personnel utilize these tools to perform tasks that otherwise would be difficult or impossible. However, these tools can be very hazardous and have the potential for causing severe injuries when used or maintained improperly. Laboratory personnel must pay special attention toward hand and power tool safety to reduce or eliminate the hazards associated with this work.

Appropriate PPE must be worn at all times when using hand and portable power tools. This includes eye protection (e.g. safety glasses or face shield), hand protection (e.g. leather gloves), foot protection (e.g. closed top/toed shoes), and appropriate attire.

1. Hand Tools

- All hand tools must be maintained in safe operating condition.
- Hand tools must be inspected before each use. Unsafe hand tools must not be used and tagged out of service.
- Hand tools must be used for the designed purpose.
- Impact tools must be free of mushroomed heads.
- Wooden handles must be free of cracks or splinters and be tight to the tool.
- Wrenches must be used when jaws are sprung to the point that slippage occurs.
- Electric power operated tools must be double-insulated or properly grounded.
- Always cut away from the body when using knives, razor blades, or utility knives. Body and hand protection must be used at all times when using these devices.

2. Portable Power Tools and Equipment

Portable power tools include but not limited to circular saws, jigsaws, drills, hammer-drills, sanders, grinders, routers, etc. These tools are designed for a wide variety of uses and save time and effort on the job. Improper use of these types of tools and equipment can result in severe injuries.

- Only authorized individuals are permitted to use power tools and equipment. The PI or supervisor must provide site specific training on the proper use of the equipment in the laboratory or work area. The training must be documented and uploaded to the documents section of BioRAFT.
- Inspect tools daily to ensure proper working order. Inspect the cord, the plug, the blade, etc. for signs of damage. Do not use damaged or defective tools. Tag out damaged tools to prevent others from using it.
- Use tools for their intended purpose.
- All power tools and electrical devices must be properly grounded. Do not use the tool if the grounding prong is missing or damaged. Tag out the tool to prevent others from using it.
- Keep guards and protective devices in place at all times. Never use equipment or tools from which guards have been removed or disengaged. Tag out the tool if the guard is missing or disengaged.
- Do not use electric power tools and equipment when standing in water.
- All extension cords must be 3-pronged type and made for hard use. Designation types must be: S, ST, STO, SJ, SJO, SJT, or SJTO.

3. Powder-Actuated Tools

- Only authorized individuals are permitted to use powder-actuated tools. The PI or supervisor must provide site specific training on the proper use of the equipment in the laboratory or work area. The training must include the manufacturers' instruction on proper use. The training must be documented and uploaded to the documents section of BioRAFT.
- Powder-actuated tools must not be left loaded and unattended.
- Used shots must be disposed properly.
- Follow all manufacturers' instructions, which must be located with the tool at all times.

4. Air Tools

- Only authorized individuals are permitted to use power tools and equipment. The PI or supervisor must provide site specific training on the proper use of the equipment in the laboratory or work area. The training must be documented and uploaded to the documents section of BioRAFT.
- Pneumatic power tools must be secured to the hose in such a way as to prevent accidental disconnection. Safety clips or retainers must be securely installed to prevent attachments from be inadvertently expelled.
- Never exceed the manufacturer's safe operating pressure for all fittings.
- Hoses exceeding ½ inch inside diameter must have a safety device at the source of supply or branch line to reduce the pressure in the event of a hose failure.

M. Machine Shop Safety

Machine shops present unique hazards distinct from those in laboratories or other work environment. Drexel University machine shop management plan establishes safety requirements for all faculty, staff, and students performing work activities in machine shops. The requirements of the plan meet and comply with all applicable university policies and the Occupational Safety and Health Administration (OSHA) regulations.

1. Responsibilities

a. Shop Supervisors

- Responsible for the safety of all employees, students, and visitors entering the machine shop.
- Develop standard operating procedures for each piece of equipment.
- Conduct site specific training for all faculty, staff, and students working with the shop. The training is required initially and annually thereafter. The training must address hazards, hours of operation, handling of equipment, appropriate dress, PPE, emergency procedures and job-specific work requirements. The training must be documented and uploaded to the documents section of BioRAFT.
- Must be present to oversee students, employees, and visitors working within the shop.
- Enforce the safety requirements established by the university.
- Inspect equipment daily to ensure proper working order. Tag out and lock out damaged or defective equipment until repaired.
- Report all incidents and injuries to EHRS at ehrs@drexel.edu.

b. Environmental Health and Safety

- Responsible for the safety of all employees, students, and visitors entering the machine shop.

- Provide general awareness training to all personnel working in the machine shop.
- Assist the shop supervisors with site specific training and standard operating procedure development.
- Conduct periodic inspections of the shops to ensure compliance with Drexel and OSHA policies.
- Conduct accident investigations.

c. Employees, Students, and Visitors

- Follow all safety procedures as specified by the shop supervisor and EHRS.
- Wear all required PPE as specified by the shop supervisor and EHRS.
- Immediately report any issue with the machine to the shop supervisor. Stop using the machine until it is repaired.
- Use the machine as the intended purpose. Do not disengaged guards or circumvent safety mechanisms.
- Know all emergency procedures in the event of an incident.
- Immediately report any incident or injury to the shop supervisor.

2. Personal Protection Equipment and Appropriate Dress

Based on the processes, equipment, and materials being utilized within the machine shops, EHRS has determined the following PPE, and proper attire is required for all faculty, staff, students and visitors when working within shops.

- Safety glasses with side shields
- Hearing protection

Appropriate dress requirements include the following:

- All hair in any shape or form has the potential be caught-in rotating machinery. However, specific significance to long hair shall be recognized. Long hair must be restrained but should not be braided. If a braid is caught-in rotating machinery, all the hair will be pulled in. The use of proper body positioning, maintaining machinery safeguards, and staying within the point of operation and out of danger zones are the best course of action to avoid having one's hair caught-in any rotating machinery.
- No jewelry (dangling earrings, bracelets, watches, necklaces, etc...) shall be worn.
- No loose-fitting clothing. All shirts must be tucked in, and all sleeves must be pulled up past elbow.
- No hooded sweatshirts with pull strings.
- No ear buds, blue tooth devices, or cell phones shall be allowed within the shop and especially used while working with equipment.
- Footwear must be closed top/toed.

The shop supervisor or EHRS may require additional PPE (i.e., work gloves, face shields, or Nomex coverings) depending on the task.

3. Safety Procedures

- All work must be supervised by the shop supervisor. Employees, students, and visitors are not permitted to work alone in the shops or work in the shop outside the hours of operation.
- All personnel must complete the general awareness and site-specific training prior to working with any machine the shop.
- Report all damaged or malfunctioning equipment to the shop supervisor. Do not use malfunctioning equipment.

- Food and drink are prohibited.
- Compressed air must not be used for cleaning skin, clothing, or work surfaces. End nozzle pressure of compressed air used for cleaning equipment may not exceed 30 psi.
- All guards and shields must remain in place during machine operation. If a guard is not present, do not use the machine. The machine must be tagged and lock out prior to removing any guard or safety device for inspection or maintenance.
- The shop floors shall be kept free of accumulations of scrap; debris, liquids (oil, water and solvents) and other slip or trip hazards.
- Machines and tools shall be cleaned after each use. Cuttings and chips shall be removed by using brushes or pliers, never by hands.
- Machinery shall only be cleaned after it has come to a complete stop, and it has been isolated from its power source.
- All walking-working surfaces including aisle ways shall be clear of slip, trip, and fall hazards. Electrical wiring and cords shall be identified, marked, and/or uncovered for full visibility. In addition, all electrical cords in use shall be either secured to the floor or suspended at a minimum seven feet from the ground.
- All electrical power sources shall be readily accessible to the operator. The operator must know how to immediately disable any machine.
- All emergency stop buttons on the machinery must be in working order.
- Power cords must be periodically inspected. Cords with exposed wiring or that are frayed must be either repaired by a qualified electrician or replaced.
- Extension cords shall only be used whenever absolutely necessary and can only be used for a short period of time. Extension cords must have a grounding conductor. Multiple plug adaptors are prohibited.
- All machines must be properly grounded.
- All energy sources shall be identified and confirmed de-energized by utilizing a physical lock or energy isolating device in conjunction with a descriptive tag during maintenance, replacing or removing guards, bypassing safety locks or repair of the equipment. **DO NOT attempt to operate any switch, valve, or other energy isolating device where equipment is locked and tagged out!**
- Machinery safeguards shall be affixed to all university equipment in order to prevent access to hazardous areas from all accessible directions including front, top, bottom, back, and sides. There are numerous examples of guarding methods including, but not limited to: fixed, interlocking, adjusting, presence sensing, restraint, tripwire controls, and gates. In addition, alternate methods such as, location, distance, automatic feeds, and protective barriers may also play a critical role in the safety of machine operators.
- Stock materials must be stored in such a manner as to prevent falling, slipping, or rolling. Materials should not be stored on the floor and may not be stored where it will impede egress from the area. Chemicals must be stored in cabinets approved for that use, as appropriate. Incompatible chemicals should not be stored together. Material Safety Data Sheets for all chemicals used must be maintained in the shop.

4. Training

All personnel must complete the university's general awareness training prior to working in the machine shop. The training is required annually. The shop supervisor must provide site specific training to all personnel requiring access the machine shop. The training is required initially and annually thereafter. The training must address hazards, hours of operation, handling of equipment, appropriate dress, PPE, emergency procedures and job-specific work requirements.

Retraining shall be conducted in response to the following circumstances:

- Whenever changes in the shop or this procedure render previous training obsolete;
- When inadequacies in the operator's knowledge or use indicates that the individual has not retained the requisite understanding or skill; and/or
- When any other situations, such as, process, equipment, and system upgrades in which retraining appears necessary.

All training must be documented and uploaded to the documents section of BioRAFT.

N. Fire Safety in the Laboratory

The UCLA Guideline on Fire Safety in the Laboratory is a great video for laboratory workers to review prior to working with flammable and combustible materials.

1. Prevention

Fire prevention is a precautionary practice applicable to all laboratories and personnel. It is a vital aspect of laboratory safety. Laboratories especially those using solvents in any quantity, have a very high potential for flash fires, explosion, rapid spread of fire, and high toxicity of secondary products of combustion (heat, smoke, chemical byproducts and flame).

2. Housekeeping

- Plan work. Most lab fires have resulted from mental or procedural errors or carelessness.
- Minimize materials in the immediate work area and use only the minimum quantities necessary to work in progress. Not only does this minimize fire risk, but it also reduces costs and waste.
- Observe proper housekeeping. Keep work areas uncluttered, and clean frequently.
- Put unneeded materials back in storage promptly.
- Keep aisles, doors, and access to emergency equipment unobstructed at all times.
- Use proper trash receptacle and do not allow trash to accumulate.
- Keep flammable liquids properly stored.
- Chemicals, especially liquids, shall never be stored on the floor.
- Stairways, hallways, passageways/aisles and access to emergency equipment and/or exits must be kept dry and not be obstructed in any fashion, including storage, equipment, phone or other wiring.
- Observe restrictions on equipment (i.e. keeping solvents only in an explosion-proof refrigerator).
- Keep barriers in place *(shields, hood doors, lab doors).*
- No combustible material such as paper, wooden boxes, pallets, etc., shall be stored under stairwells or in hallways. Hallways shall be kept free of boxes and materials so that exits or normal paths of travel will not be blocked.
- All chemical containers must be labeled with the full product name, hazard warnings or symbols, and the responsible party. Refer to the University's Chemical Hygiene Plan for more details concerning chemical container labeling.
- Follow the electric safety as described in Section K above.

3. Fire Detection and Responding to Fire

It is important that you and your staff are prepared to respond to fires and other emergencies. Review this basic, but critical, fire response information with your team on a regular basis. Follow the "R.A.C.E." acronym if there is a fire or suspected fire: **Rescue – Alarm – Contain – Extinguish.**

Rescue

- Immediately stop what you are doing and remove anyone in immediate danger from the fire to a safe area.
- Ambulatory persons should be instructed to leave under their own power and report to the Approve Assembly Area.
- Persons that require assistance with ambulation should be assisted to the Area of Refuge.
- Get out as safely and quickly as possible. The less time you and others are exposed to poisonous gases, heat, or flames, the safer everyone will be.
- Assist/ensure evacuation per instructions from the Disaster Leader according to the Emergency Evacuations section of this manual.
- Be familiar with Drexel Emergency Preparedness Program. The plan identifies roles, behaviors, and communications in emergencies; calls for the formation of teams, structures training, and defines notification of three campuses; and is comprised of three components (preparedness and training, notification and action, and collaboration with partners.

Alarm

- Activate the nearest fire alarm pull stations (if applicable).
- Call 911 and/or the Drexel University Communications Center to report the location and current extent of the fire.

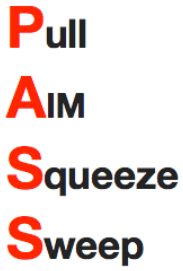
Contain

- Close all doors and windows that you can safety reach to contain the fire. During evacuation close the doors behind you.

Extinguish

- Only attempt to extinguish the fire if it is safe for you to do so.
- Retrieve the nearest fire extinguisher and follow the "P.A.S.S." procedure:

  P = Pull the pin breaking the plastic seal;
  A = Aim at the base of the fire;
  S = Squeeze the handles together; and
  S = Sweep from side to side.



4. Fire Extinguishers

- Laboratory personnel should be adequately trained regarding pertinent fire hazards associated with their work. Training of employees in the use of fire extinguishers is required by OSHA 29 CFR 1910.157(g), "...where the employer has provided portable fire extinguishers for employee use in the workplace." Such training shall be conducted at initial employment and annually thereafter.
- Fire extinguishers should never be concealed from general view or blocked from access.
- In order to choose the right type of fire extinguisher, you must know what type of fire you are attempting to control.
- Fire extinguisher must be inspected monthly. Laboratory personnel must check the pressure, pin, and hose condition. The inspection must be documented by dating the annual certification card.
- If you are not sure of type of fire, leave the area and activate the fire alarm
- There are four types of extinguishers that are labeled as to which of the four types of fire they are effective in controlling.
- Three main classes of fire are shown below.

Class A:	Fires with trash, wood, paper, or other combustible materials
Class B:	Fires with flammable or combustible liquids
Class C:	Fires involving electrical equipment

Building occupants are not required to fight fires. DO NOT attempt to fight a fire. Individuals who have been trained in the proper use of a fire extinguisher and are confident in their ability to cope with the hazards of a fire may use a portable fire extinguisher to fight small fires (no larger than a wastepaper basket). Fire-fighting efforts must be terminated within 15 seconds, or when it becomes obvious that there is risk of harm from smoke, heat or flames, whichever comes FIRST. Remember R.A.C.E. Exercise good judgment. Use the fire extinguisher if a fire has come between you and the exit. If you do need to operate an extinguisher in an emergency, remember, P.A.S.S.

5. What to Do When Fire Alarm Sounds

The Department of Public Safety promotes and supports a safety-conscious campus through professional consultation, education, training, and delivery of services designed to provide a fire-safe environment for the Drexel University community. When the fire alarm sounds, leave the laboratory and the building using the nearest or designated fire for exit or smoke compartment. Building specific fire evacuation plans for university space are located near the elevator lobby. **Never** use an elevator to exit during fire alarm activation. **Never** ignore or assume the alarm is false or the result of a test. Gather outside at a designated assembly area, and do not attempt to re-enter the building until instructed to do so by Drexel's Public Safety Department. Unauthorized re-entry into a building during a fire emergency is not permitted. Violators of this policy are subject to university and state fire code sanctions.

O. Thermometers

Use of mercury thermometers is not harmful when properly used but do pose a threat to the environment when they are broken or disposed as trash. Broken mercury thermometers cause mercury to spill out into the environment leading to potential exposures to laboratory personnel. Mercury thermometers when they break in ovens or incubators may lead to high mercury concentrations in the air since mercury evaporates readily at high temperatures. Alternatives to the use of mercury thermometers must be considered since

they are as effective and affordable. Available alternatives include spirit filled, alcohol filled or microprocessor-digital readout thermometers.

EHRS has over the past several years implemented a mercury thermometer exchange program. This program has drastically reduced the number of mercury thermometers utilized in research. Contact EHRS at ehrs@drexel.edu to exchange mercury thermometers.

Broken mercury thermometers and mercury spills are considered **major spill events** because mercury breaks into very small droplets and can spread over a large area. In the event of a broken mercury thermometer in the laboratory, the major spill response procedures as outlined below must be implemented:

1. Immediately isolate the area.
2. Do not touch or move the thermometer or sweep of the broken pieces.
3. Notify all personnel in the immediate area that a spill has occurred.
4. If clothes become contaminated remove contaminated clothing and leave in the area of the spill. If skin, eye or body contamination has occurred immediately decontaminate using the eyewash or safety shower. Refer to the personal decontamination procedures in this manual.
5. Evacuate room and close door.
6. Contact the Public Safety 24 Hour Call Center at 215-89-2222.
7. In order to assess the situation be prepared to provide the following information:
    a. Name and call back number.
    b. The location of the spill (building and room number).
    c. The amount of material spilled.
8. Remain on or near the telephone until you have received instructions from Public Safety or EHS.

P. Safety Showers

- Familiarize yourself with the location of the nearest safety shower.
- Familiarize yourself with the operation of safety shower.
- Safety showers are designed to flood the entire body in the event of a clothing fire or a major spill of a chemical. In either case, you should simply stand under the shower and activate the shower. Flood the affected area for a minimum of 15 to 30 minutes.
- In the case of a corrosive liquid spill, the employee should remove the affected portion of clothing to reduce potential contact. Removal of clothing should be done while the individual is under the activated shower.
- The departmental chemical hygiene officer or laboratory supervisor shall be notified as soon as possible if the employee required the use of the safety shower.
- Safety showers are tested annually by EHRS.

Q. Eye Wash Units

- Familiarize yourself with the location and operations of nearest eyewash fountain.
- Always flood the eyes for **at least 15 to 30 minutes** to be sure there is no residue of the corrosive liquid. Flush from the eye outward.
- After thorough washing, the proper authorities shall be notified and subsequent medical care for the employee must be seriously considered. This is because serious damage may have already occurred before the eye was thoroughly rinsed and/or the damage may not be immediately apparent.
- Eyewash units must be tested weekly by laboratory personnel for proper operation.

R. Refrigerators, Explosion Proof Refrigerators & Freezers

The potential hazards posed by laboratory refrigerators and freezers involve vapors from the contents, the possible presence of incompatible chemicals and spillage.

Only refrigerators and freezers specified for laboratory use should be utilized for the storage of chemicals. These refrigerators have been constructed with special design factors, such as heavy-duty cords and corrosion resistant interiors to help reduce the risk of fire or explosions in the lab.

Standard refrigerators, such as those sold for household use, have electrical fans and motors that make them potential ignition sources for flammable vapors. Do not store flammable liquids in a refrigerator unless it is approved for such storage. Flammable liquid-approved refrigerators are designed with spark-producing parts on the outside to avoid accidental ignition. If refrigeration is needed inside a flammable-storage room, you must use an explosion-proof refrigerator.

Frost-free refrigerators should also be avoided. Many of them have a drain or tube or hole that carries water and possibly any spilled materials to an area near the compression, which may spark. Electric heaters used to defrost the freezing coils can also spark.

Only chemicals shall be stored in chemical storage refrigerators; lab refrigerators shall not be used for food storage or preparation. Refrigerators must be labeled for their intended purpose; labels reading “No Food or Drink to be Stored in this Refrigerator” or “Refrigerator for Food Only” are available from EHRS by contacting EHRS at ehrs@drexel.edu.

All materials in refrigerators or freezers shall be labeled with the contents, owner, date of acquisition or preparation and nature of any potential hazard. Since refrigerators are often used for storage of large quantities of small vials and test tubes, a reference to a list outside of the refrigerator could be used. Labels and ink used to identify materials in the refrigerators should be water-resistant.

All containers must be sealed, preferably with a cap. Containers should be placed in secondary containers or catch pans should be used.

Loss of electrical power can produce extremely hazardous situations. Flammable or toxic vapors may be released from refrigerators and freezers as chemicals warm up and/or certain reactive materials may decompose energetically upon warming. Proactive planning can avoid product loss and hazardous situations in event of an extended power outage. Dry ice or alternate power sources can be used to prevent refrigerator and freezer contents from warming.

Laboratory refrigerators and freezers stored in common or departmental areas must have the contact information for the laboratory that is using them. This will allow Facilities and/or other emergency responders contact a laboratory representative if any questions are needed to be asked or if there is an emergency, such as a power failure.

Special explosion proof freezers are required for the storage of unstable and/or flammable materials. Do not, under any circumstance, place these items in normal (non-explosion proof) refrigerators or freezers.

S. Absorbent Paper

Plastic-backed absorbent paper on laboratory bench tops will help control spills only if it is placed with its plastic side down. This paper should not be secured with tape and should be removed at the end of each work shift or immediately following any incidental spills.

T. Disinfectants

Several studies have shown that disinfectants containing sodium hypochlorite (Clorox and Alcide) are at least four times more effective than solutions of 70% alcohol, iodine compounds, phenolic and ammonium compounds.

U. Pressure Vessels

Pressure vessels present a significant risk to personnel when working at high pressure and with hazardous materials. Improper design or use of a pressure can cause explosion. As such, high pressure operations must only be performed in special chambers equipped for this purpose. Laboratory personnel must ensure that equipment for operation using pressure vessels is appropriately selected, labeled, properly installed and protected by pressure relief devices. When working with pressure vessels, take the following precautions:

- The vessel must be strong enough to withstand the stresses encountered at the intended operating pressures and temperatures.
- The vessel must not corrode when it is in contact with the material it contains. The vessel material should not react with the process being studied.
- The vessel must of proper size and configuration needed for the process.
- Pressure containing systems designed for use at elevated temperatures must have a temperature controller capable of shutting down the system automatically.
- Each pressure vessel must be labeled with the maximum allowable working pressure, allowable temperature at this pressure, material of construction, and burst diagram.
- Final assemblies must be pressure tested and leaked tested prior to use to ensure proper assembly.
- When working with flammable gas mixtures, the system must be designed to prevent static charges and ignitions sources. All vessels must be grounded to reduce the likelihood of ignition of flammable mixtures.
- All pressure equipment must be inspected annually. In some cases, the equipment must be inspected more frequently due to the process. Personnel must keep records of all inspections, repairs, and modifications.
- All pressure vessels must have a standard operating procedure for all personnel to review. Personnel must receive hazard specific training on the hazards and proper operation. The training must be documented and uploaded to the university's compliance platform.

1. Autoclaves

The use of an autoclave is a very effective way to decontaminate infectious waste. Autoclaves work by killing microbes with superheated steam. Adherence to the following precautionary measures will increase operational efficiency and help prevent accidents.

- Autoclaves must be checked periodically to ensure the seals to the closures are in good condition.
- Pressure relief devices must be present to prevent excessive pressures and temperatures.

- Do not attempt to open the autoclave during a cycle.
- Wait until the materials are cooled prior to removing from the autoclave.
- Liquids placed inside sealed containers may explode. Liquids in ordinary glass containers instead of Pyrex containers may rupture.
- Do not place flammable liquids or chemicals which could become unstable at elevated temperatures.
- Operating instructions and a list of good safety practices must be posted near any autoclave for review.

Under Title 25 Chapter 271 of the Pennsylvania Code, any facility that autoclaves regulated medical waste is considered to be a "permit by rule" waste processing facility. As such, the following operating procedures have been developed to ensure that university laboratories fulfill the requirements outlined in Chapter 271 of Title 25.

- A log must be kept at the autoclave site. The log must contain the following information:
  - The date of the run.
  - Name of person making the run.
  - Materials being autoclaved.
  - Time and temperature of the run.
  - The person's signature.
- Each and every run of the autoclave must be noted in the log.
- Upon reaching the 40-hour run mark, a biological indicator test must be run in the autoclave to ensure that the equipment is running properly. The test kits may be obtained through suppliers such as Fisher Scientific, Grainger, etc. This indicator test must be performed for every 40 hours of autoclave run time.
- The results of the biological indicator test must be noted in the log, along with the date, name of person running the test, and the person's signature.
- Should the autoclave fail the indicator test, EHRS must be notified and the equipment must be placed out of service until the proper repairs can be completed and verified with an indicator test.
- EHRS will perform monthly inspections of autoclaves and autoclave logs to ensure that the requirements of this operation procedure are being fulfilled.
- If the conditions of this standard operation procedure are not met, EHRS will lock out the autoclave until this policy is reviewed with the responsible party and appropriate changes are made.

Contact EHRS at ehrs@drexel.edu if you have any questions or concerns with autoclaving regulated medical waste.

V. Stirring and Mixing Devices

The stirring and mixing devices commonly found in laboratories include stirring motors, magnetic stirrers and shakers, small pumps for fluids and rotary evaporators for solvent removal. These devices are typically used in laboratory operations that are performed in a hood, and it is important that they be operated in a way that precludes the generation of electrical sparks.

Only spark-free induction motors should be used in power stirring and mixing devices or any other rotating equipment used for laboratory operations. While the motors in most of the currently marketed stirring and mixing devices meet this criterion, their on-off switches and rheostat-type speed controls can produce an electrical spark because they have exposed electrical conductors. The speed of an induction motor operating under a load should not be controlled by a variable autotransformer.

Because stirring and mixing devices, especially stirring motors and magnetic stirrers, are often operated for fairly long periods without constant attention, the consequences of stirrer failure, electrical overload or blockage of the motion of the stirring impeller should be considered.

W. Heating Devices

Most labs use at least one type of heating device, such as ovens, hot plates, heating mantles and tapes, oil baths, salt baths, sand baths, air baths, hot-tube furnaces, hot-air guns and microwave ovens. Steam-heated devices are generally preferred whenever temperatures of 100° C or less are required because they do not present shock or spark risks and can be left unattended with assurance that their temperature will never exceed 100° C. Ensure the supply of water for steam generation is sufficient prior to leaving the reaction for any extended period of time.

1. General Precautions

A number of general precautions need to be taken when working with heating devices in the laboratory. When working with heating devices, take the following precautions:

- The actual heating element in any laboratory heating device should be enclosed in such a fashion as to prevent a laboratory worker or any metallic conductor from accidentally touching the wire carrying the electric current.
- Heating device becomes so worn or damaged that its heating element is exposed; the device must be taken out of service immediately for repair by a qualified person or discarded.
- Laboratory heating devices should be used with a variable autotransformer to control the input voltage by supplying some fraction of the total line voltage, typically 110 V.
- The external cases of all variable autotransformers have perforations for cooling by ventilation and, therefore, should be located where water and other chemicals cannot be spilled onto them and where they will not be exposed to flammable liquids or vapors.

Fail-safe devices can prevent fires or explosions that may arise if the temperature of a reaction increases significantly because of a change in line voltage, the accidental loss of reaction solvent or loss of cooling. Some devices will turn off the electric power if the temperature of the heating device exceeds some preset limit or if the flow of cooling water through a condenser is stopped owing to the loss of water pressure or loosing of the water supply hose to condenser.

2. Oven and Furnaces

Electrically heated ovens and furnaces are commonly used in the laboratory to remove water or other solvents from chemical samples and to dry laboratory glassware. Never use laboratory ovens or furnaces for human food preparation.

- Laboratory ovens and furnaces must be constructed such that their heating elements and their temperature controls are physically separated from their interior atmospheres.
- All ovens and furnaces must be equipped with a backup thermostat or temperature controller to either control the unit should the primary one fail or shut the oven down. Units with only a single thermostat must not be used for long, unattended processes.
- All ovens and furnaces must be equipped with automatic shut off controls to prevent temperature spikes above the working set point.

- Laboratory personnel must develop standard operating procedures for the proper use of ovens and furnaces. The manufacturer's operating manual must be present at the oven or furnace for review.
- All laboratory personnel needing to use an oven or furnace must be trained on the proper operation. The training must be documented and uploaded to the university's compliance platform.
- Laboratory ovens and furnaces must be exhausted to local exhaust system. Placing ovens or furnaces in a chemical fume hood is not permitted unless it is dedicated for the oven alone.
- Ovens furnaces should not be used to dry any chemical sample that might pose a hazard because of acute or chronic toxicity unless special precautions have been taken to ensure continuous venting of the atmosphere inside the oven.
- Ovens and furnaces suitable for heating materials, which contain flammable liquids, must be utilized. These ovens must have explosion vents on the rear of the unit.
- To avoid explosion, glassware that has been rinsed with an organic solvent must be rinsed again with distilled water before being dried in an oven.
- Bimetallic strip thermometers are preferred for monitoring oven temperatures. Mercury thermometers should not be mounted through holes in the top of ovens so that the bulb hangs into the oven. Should a mercury thermometer be broken in an oven of any type, the oven must be closed and turned off immediately, and it must remain closed until cool. Immediately implement major spill procedures to have mercury cleaned up by EHRS.

3. Hot Plates

Laboratory hot plates are normally used for heating solutions to 100º C or above when inherently safer steam baths cannot be used. Any newly purchased hot plates should be designed in a way that avoids electrical sparks. However, many older hot plates pose an electrical spark hazard arising from either the on-off switch located on the hot plate, the bimetallic thermostat used to regulate the temperature or both. Laboratory workers should be warned of the spark hazard associated with older hot plates.

In addition to the spark hazard, old and corroded bimetallic thermostats in these devices can eventually fuse shut and deliver full, continuous current to a hot plate.

- Do not store volatile flammable materials near a hot plate
- Where possible, avoid using older hot plates for flammable materials.
- Check for corrosion of thermostats. Hot plates with corroded bimetallic thermostats shall be taken out of service immediately and repaired by qualified personnel. Contact EHRS for more info.

4. Heating Mantles

Heating mantles are commonly used for heating round-bottomed flasks, reaction kettles and related reaction vessels. These mantles enclose a heating element in a series of layers of fiberglass cloth. As long as the fiberglass coating is not worn or broken, and as long as no water or other chemicals are spilled into the mantle, heating mantles pose no shock hazard.

- Always use a heating mantle with a variable autotransformer to control the input voltage. Never plug them directly into a 110-V line.
- Be careful not to exceed the input voltage recommended by the mantle manufacturer. Higher voltages will cause it to overheat, melt the fiberglass insulation and expose the bare heating element.

- If the heating mantle has an outer metal case that provides physical protection against damage to the fiberglass, it is good practice to ground the outer metal case to protect against an electric shock if the heating element inside the mantle shorts against the metal case.
- Some older equipment might have asbestos insulation rather than fiberglass. Contact EHRS for proper disposal of the asbestos.

5. Oil, Salt and Sand Baths

Electrically heated oil baths are often used to heat small or irregularly shaped vessels or when a stable heat source that can be maintained at a constant temperature is desired. Molten salt baths, like hot oil baths, offer the advantages of good heat transfer, commonly have a higher operating range (e.g., 200 to 425ºC) and may have a high thermal stability (e.g., 540ºC). Take the following precautions when working with these types of heating devices.

- Take care with hot oil baths not to generate smoke or have the oil burst into flames from overheating.
- Always monitor oil baths by using a thermometer or other thermal sensing devices to ensure that its temperature does not exceed the flash point of the oil being used.
- Heating baths must be equipped with redundant heat controls or automatic cutouts should the temperature regulating circuits fail.
- Fit oil baths left unattended with thermal sensing devices that will turn off the electric power if the bath overheats.
- Mix oil baths well to ensure that there are no “hot spots” around the elements that take the surrounding oil to unacceptable temperatures.
- Contain heated oil in a vessel that can withstand an accidental strike by a hard object.
- Mount baths carefully on a stable horizontal support such as a laboratory jack that can be raised or lowered without danger of the bath tipping over. Iron rings are not acceptable supports for hot baths.
- Clamp equipment high enough above a hot bath that if the reaction begins to overheat, the bath can be lowered immediately and replaced with a cooling bath without having to readjust the equipment setup.
- Provide secondary containment in the event of a spill of hot oil.
- Heating baths must not be placed near flammable and combustible material or near sources of water.
- Wear heat-resistant gloves when handling a hot bath.
- The reaction container used in a molten salt bath must be able to withstand a very rapid heat-up to a temperature above the melting point of salt.
- Take care to keep salt baths dry since they are hygroscopic, which can cause hazardous popping and splattering if the absorbed water vaporizes during heat-up.

6. Hot Air Baths and Tube Furnaces

Hot air baths are used in the lab as heating devices. Nitrogen is preferred for reactions involving flammable materials. Electrically heated air baths are frequently used to heat small or irregularly shaped vessels. One drawback of the hot air bath is that they have a low heat capacity. As a result, these baths normally have to be heated to 100ºC or more above the target temperature. Tube furnaces are often used for high-temperature reactions under pressure. Consider the following precautions when working with either apparatus.

- Ensure that the heating element is completely enclosed.
- For air baths constructed of glass, wrap the vessel with heat resistant tape to contain the glass if it should break.
- Sand baths are generally preferable to air baths.

- For tube furnaces, carefully select glassware and metal tubes and joints to ensure they are able to withstand the pressure.
- Follow safe practices outlined for both electrical safety and pressure and vacuum systems.

7. Heat Guns

A heat gun is similar in appearance to a standard hairdryer but is operated and used in a vastly different manner. Both are constructed with a motor-driven fan that blows air over an electrically heated filament. The heating element in a heat gun typically becomes red-hot during use. Heat guns operate at lower air speeds and produce temperature as high as 1200F, hot enough to melt some types of glass.

Laboratory heat guns are constructed with a motor-driven fan that blows air over an electrically heated filament. They are frequently used to dry glassware or to heat the upper parts of a distillation apparatus during distillation of high-boiling materials.

Basic heat guns have one heat setting and one fan speed and are designed primarily for paint stripping. More complicated models have two or three heat settings or variable adjustment within a range, together with a choice of two, three or variable speeds of air flow.

Safety considerations you should keep in mind when using a heat gun.

- Do not use a heat gun near combustible or flammable materials/atmospheres.
- Keep in mind the presence and direction of the heat produced
- Always switch the tool off before putting it down on any surface.
- Allow the tool to cool before storing it.
- Never touch the hot metal nozzle with clothing or skin.
- Never direct the air flow towards one's body
- Do not look down the nozzle while the gun is turned on.
- Do not insert anything down the nozzle of the gun.
- Never block the inlet grill or obstruct the air flow of the unit while in operation

Do not use an extension cord to power a heat gun. Due to the high current draw, extension cords may overheat and pose a risk of a fire or electric shock. Never obstruct or cover the air inlet grills. If the air flow is reduced the heat gun will overheat and possible catch fire. Never operate the heat gun with the outlet nozzle directly against a surface, this will reduce the air flow and can have the same effect as obstructing the air inlet grills.

8. Microwave Ovens

Microwave ovens used in the laboratory may pose several different types of hazards.

- As with most electrical apparatus, there is the risk of generating sparks that can ignite flammable vapors.
- Metals placed inside the microwave oven may produce an arc that can ignite flammable materials.
- Materials placed inside the oven may overheat and ignite.
- Sealed containers, even if loosely sealed, can build pressure upon expansion during heating, creating a risk of container rupture.

To minimize the risk of these hazards, apply procedures listed below.

- Never operate microwave ovens with doors open in order to avoid exposure to microwaves.
- Do not place wires and other objects between the sealing surface and the door on the oven's front face. The sealing surfaces must be kept absolutely clean.
- Never use a microwave oven for both laboratory use and food preparation.
- Electrically ground the microwave. If use of an extension cord is necessary, only a three-wire cord with a rating equal to or greater than that for the oven must be used.
- Do not use metal containers and metal-containing objects (e.g., stir bars) in the microwave. They can cause arcing.
- Do not heat sealed containers in the microwave oven. Even heating a container with a loosened cap or lid poses a significant risk since microwave ovens can heat material so quickly that the lid can seat upward against the threads and containers can explode.
- Remove screw caps from containers being microwaved. If the sterility of the contents must be preserved, use cotton or foam plugs. Otherwise plug the container with Kim wipes to reduce splash potential.

As stated for refrigerators above, microwaves must be labeled for their intended purposes. Microwaves must be labeled either "Not for Use for Food or Drink" or "Microwave for Food Only".

X. Hydrothermal Autoclave Reactors

The hydrothermal autoclave reactor is a stainless-steel vessel with a screw cap and an internal cup and lid made of Teflon. These reactors are charged with reagents, closed, and heated for the desired result. The reactors are specifically designed for harsh chemicals, high temperatures and high pressures. This plan is intended to inform on safe working practices to follow whenever autoclave reactors are utilized in the laboratory. The following procedures must be reviewed by all laboratory personnel prior to conducting any experiment involving hydrothermal autoclave reactors.

1. Hazards

Autoclave reactors present an explosion risk when the temperature and pressure exceed the maximum operating temperature and working pressure of the reactor. The high temperatures can cause severe burns to the body. Laboratory personnel can be exposed to chemicals while charging the reactor. In addition, the laboratory personnel can be exposed to the chemicals in the reactor if the reactor fails.

2. Standard Practices

Laboratory personnel must wear the required personal protection equipment. The University's minimum requirement is as follows:

- Safety Glasses or Splash goggles
- Lab coat
- Pants
- Closed top, closed back, and closed toe shoes.

A face shield must be worn over top of the safety glasses or splash goggles if there is a potential for an explosion. Gloves must be worn if there is a potential for exposure to chemicals. The appropriate glove must be selected using glove selection charts or the safety data sheet (SDS). Insulated glove must be worn if there is a potential for exposure to high temperatures.

3. Safe Use Requirements

- Each autoclave reactor must be marked with unique number. The number must be visible and placed on all parts of the reactor.
- The maximum operating temperature and working pressure must be labeled on each reactor. The manufacturer of the reactor will provide these values.
- Do not exceed the maximum operating temperature and working pressure for the reactor. Laboratory personnel must include these values in the laboratory's specific standard operating procedure. Each reactor has a specific maximum operating temperature and working pressure.
- Review the manufacturer's vapor pressure tables to ensure the pressure will not exceed the maximum working pressure.
- **Autoclave reactors must be equipped with safety blow-off discs**. **Reactors that do not have this feature are strictly prohibited for use.** The blow-off feature consists of an area with an intentionally weakened structure allowing the reactor to fail in a predictable and reasonably safe manner in the event of over pressurization. The burst pressure is established by a frangible metal disc installed as a sandwich with a matching inner disc which services as a corrosion barrier to protect the main disc from corrosive vapor.
- Mix-matching of lids to bodies is not permitted. Only matched autoclave reactor parts are to be used.
- Laboratory personnel shall not operate the reactors unless the reactor is in good repair.
- Laboratory personnel must not make repairs to the reactors. Autoclaves shall be maintained and repaired by qualified persons.
- If the autoclave reactor does not operate exactly as expected, a notice shall be placed on the reactor indicating that it is not to be used until the problem is diagnosed and corrected.
- Stringent visual inspections of the reactors must be performed every six (6) months to examine their structural integrity. The reactor must be taken out of use if there is any evidence of damage, deterioration or metal creep on the thread of the reactor body, lid or other stainless-steel components. This inspection must be documented and uploaded to the BioRAFT system.
- Before every use both the stainless-steel shell and the Teflon liner must be visually inspected for cracks, pitting, rust, metal creep or excessive wear. Steel shells that are cracked or flawed in any way must be discarded. Worn or distorted Teflon liners must be replaced.
- When charging the reactor with reagents, the Teflon liner should not be filled more than **66 percent (filling fraction, ~15 mL depending on the reactor size) but some reactions may require additional volume.** The charging limit will ensure that there is sufficient headspace for vapor formation and fluid expansion when the reactor is heated.
- Reagents used in the reactor must not react to release gas. This will lead to excessive pressure build-up.
- Nitric acid must not be used with organic materials to prevent the formation of nitro explosives.
- Reactions which are highly exothermic, or which release large quantities of gas (such as an oxidant and an organic compound) must not be performed in the reactor.
- Perchloric acid must NEVER be used in the reactor.
- Laboratory personnel must label the furnace, oven, oil or water bath or sand bath heating the reactor with hazard communication signage for each experiment. The sign must contain the following:

    - "Hazardous Process Underway – Do Not Change the Temperature – Immediately Contact the Responsible Party if the Temperature of the Heating Device Exceeds the Reaction Temperature List Below".
    - The reaction temperature.
    - The name of the responsible party.

- The telephone number of the responsible party.
- Contents of the reactor.

- Preparation of the reactor for heating shall be performed as follows:

  - Place the desired reagents into the Telfon liner.
  - Place the stainless-steel bottom plate into stainless steel reactor body and ensure that the bottom plate is in the correct place.
  - Ensure that the lip of the Teflon liner is free from any liquid/solid by gently cleaning with a Kimwipe.
  - Place the Teflon lid onto the Teflon Liner. Nothing should impede good contact between the lid and liner.
  - Gently place the charged Teflon liner into the reactor body.
  - Place the stainless-steel top plate onto the Teflon lid.
  - Screw the stainless-steel screw cap on the reactor body assembly until hand tight. Keep reactor on the benchtop to tighten to avoid spilling the contents.
  - Place reactor in a vice to tighten the screw cap with the steel rod. Do not overtighten.
  - Place reactor in heating device. Set the high temperature set point on the heating device to ensure the temperature does not exceed the maximum operating temperature.
  - Set the reaction temperature.
  - Label the heating device with the required signage.
  - Record in a logbook the contents of the reactor, reactor number, responsible party, telephone number, run time, and date.

- Unloading the reactor shall be performed in the following manner:

  - Turn off the oven.
  - Use heat-insulating gloves to remove the reactor. Lab personnel may need to wear a face shield.
  - Place the reactor on a thermal-resistant plate or ceramic brick to cool down.
  - Allow the reactor to cool down naturally. **Do not quench the temperature by placing the reactor in cold water.**
  - Once completely cooled, secure the reactor in a vice and unscrew the cap with the stainless-steel bar. **Only open the reactor when completely cooled.**
  - Remove the reactant from the Teflon liner. Clean the Teflon liner and dry. Place all reactor parts into the designated storage area. Ensure all matched reactor parts are stored together.

Y. Ultrasonicators

Human exposure to ultrasound with frequencies between 16 and 100 kilohertz (kHz) can be divided into three distinct categories: airborne conduction, direct contact through a liquid coupling medium, and direct contact with a vibrating solid.

Ultrasound through airborne conduction does not appear to pose a significant health hazard to humans. However, exposure to the associated high volumes of audible sound can produce a variety of effects, including fatigue, headaches, nausea and tinnitus. When ultrasonic equipment is operated in the laboratory, the apparatus must be enclosed in a 2-cm thick wooden box or in a box lined with acoustically absorbing foam or tiles to substantially reduce acoustic emissions (most of which are inaudible).

Direct contact of the body with liquids or solids subjected to high-intensity ultrasound of the sort used to promote chemical reactions must be avoided. Under sonochemical conditions, cavitation is created in

liquids, and it can induce high-energy chemistry in liquids and tissues. Cell death from membrane disruption can occur even at relatively low acoustic intensities.

Exposure to ultrasonically vibrating solids, such as an acoustic horn, can lead to rapid frictional heating and potentially severe burns.

Z. Centrifuges

Centrifuges must be properly installed and must be operated only by trained personnel. It is important that the load is balanced each time the centrifuge is used and that the lid is closed while the rotor is in motion. The disconnect switch must be working properly to shut off the equipment when the top is opened, and the manufacturer's instructions for safe operating speeds must be followed.

1. Maintenance and Installation Safety

- Laboratory personnel must read the centrifuge instruction manual prior to performing any work with a centrifuge.
- Only a qualified representative from the centrifuge company shall install centrifuges.
- If a centrifuge needs to be moved, a qualified representative from the centrifuge company must reinstall and re-level the instrument in its new location.
- If an anchoring or anti-rotation system is provided or is available for the centrifuge, be sure to use it to keep the instrument in place. These systems are designed to reduce the possibility of injury or damage that could result from centrifuge movement in the event of a major rotor mishap.
- Preventative maintenance (PM) checks shall be performed annually. A qualified representative from the centrifuge company shall only perform these checks. Units must be labeled with the last inspection date and when the next inspection is due.
- Bench top centrifuges shall be securely anchored in a location where its vibration will not cause bottles or equipment to fall.
- Check O-rings on containers and rotors for cracks, nicks or chemical attack. Apply vacuum grease to the seals at least weekly.

2. Rotor Safety

- Use only the rotors and accessories designed for use in the centrifuge.
- Be gentle with aluminum rotors. Avoid harsh detergents or bottle brushes with sharp wire ends especially when cleaning aluminum rotors. Finish rinsing with de-ionized water.
- Do not use sharp tools on the rotor that could cause scratches in the rotor surface. Corrosion begins in scratches and may open fissures in the rotor with continued use.
- Inspect rotors regularly. If there are rough spots, pitting, white powder deposits, or heavy discoloration, do not run the rotor. Have it checked by the manufacturer's representative.
- Keep rotors clean and dry. Regularly clean rotors and buckets with non-corrosive cleaning solutions.
- Maintain rotor log. Eventually every rotor must be retired and as ultra-rotors age, their maximum speed must be degraded. It is imperative to keep diligent logs.
- Before placing the rotor in the centrifuge, make sure the bowl is dry, and the drive spindle is clean.
- Make sure the rotor is seated on the drive hub correctly.
- Use only components and accessories designed for use in the rotor being centrifuged. Refer to the rotor manual to determine the specifications for the components and accessories.

- Pretest lab ware in the rotor, using buffer or gradient of equivalent density to the intended sample solution, to determine optimal operating conditions.
- To prevent plug damage on vertical tube or near vertical tube rotors, do not use rotor plugs or spacers in empty cavities. Leave unused cavities completely empty.
- Ensure that the buckets (or carriers) are properly hooked to the crossbars or pivot pins of swinging bucket rotors. A mis-hooked bucket cannot swing freely to a horizontal position during centrifugation and could cause a rotor mishap. Attach all buckets, loaded or empty, to the rotor as described in the rotor manual.
- Before starting the centrifuge, make sure that the rotor tie-down device (in centrifuges requiring them) is securely fastened.
- Do not exceed the maximum rated speed for the rotor in use.
- Do not leave the centrifuge until full operating speed is attained and the machine appears to be running safely without vibration.
- If vibration occurs, stop the centrifuge immediately and check the counter-balance load. Check swing-out buckets for clearance and support.
- Never attempt to slow or stop the rotor by hand.
- Never operate the centrifuge with the door/lid open.
- Do not lift or move the centrifuge while the rotor is spinning.
- Never attempt to override the door interlock system while the rotor is spinning.
- In the event of a power failure, do not attempt to retrieve the sample from the centrifuge for at least one hour. Follow the instructions for recovery of the sample in the instruction manual.

3. Sample Balancing

- Balance tubes and bottles as closely as possible and avoid overfilling.
- Do not overload beyond the rotor's maximum mass without reducing the rated rotor speed.
- Plastic centrifuge tubes must be used whenever possible to minimize breakage.
- Tubes to be used in angle-head centrifuges must never be filled to the point that liquid is in contact with the lip of the tube when it is placed in the rotor, even though the meniscus will be vertical during the rotation. When the tube lip is wetted, high G forces drive the liquid past the cap seal and over the outside of the tube.
- Nitrocellulose tubes must only be used when clear, without discoloration, and flexible. It is advisable to purchase small lots several times a year rather than one large lot. Storage at 4 ℃ extends shelf life.
- Nitrocellulose tubes must not be used in angle-head centrifuges.

4. Chemical Safety

- Do not place containers holding liquid on or near the chamber door. If they spill, liquid may get into the centrifuge and damage electrical or mechanical components.
- The centrifuge is not designed for use with materials capable of developing flammable or explosive vapors. Do not centrifuge such materials in the instrument nor handle or store them near the centrifuge.
- If laboratory personnel intend to use toxic or radioactive samples in the centrifuge, it is the responsibility of the user to ensure that all necessary safety regulations, guidelines, precautions, and practices are adhered to accordingly. Contact EHRS at ehrs@drexele.edu for advice concerning the level of containment required and about proper decontamination or sterilization procedures to follow if fluids escape from their containers.
- Wait ten minutes before opening the centrifuge door in order to avoid hazardous aerosols. Utilize aerosol containment tubes when applicable.

- When the run is completed, do not open the door until the rotor has come to a halt. Always check for a possible leakage. If disassembly reveals evidence of leakage, assume that some fluid escaped the rotor. Apply all appropriate decontamination procedures to the centrifuge and accessories.
- If glass tubes break, remove the glass very carefully from the adapters, buckets, or rotor cavities. Examine and clean the gasket and/or chamber bowl with care because glass fragments may have become embedded in them.
- Dispose of all waste solutions according to the University's Hazardous Waste Disposal plan.

5. Biological Safety

- If laboratory personnel intend to use pathogenic, toxic, or radioactive samples in the centrifuge, it is the responsibility of the user to ensure that all necessary safety regulations, guidelines, precautions, and practices are adhered to accordingly. Contact EHRS at ehrs@drexel.edu for advice concerning the level of containment required and about proper decontamination or sterilization procedures to follow if fluids escape from their containers.
- Instrument O-rings are not designed as bioseals for aerosol or liquid containment.
- Always choose aerosol containment tubes and rotors when centrifuging infectious materials.
- Load and unload tubes and rotors in a biological safety cabinet.
- Wait ten minutes before opening the centrifuge door in order to avoid hazardous aerosols. Utilize aerosol containment tubes when applicable.
- If there is evidence of leakage or damage of any kind, close the lid immediately and carefully plan the cleanup.
- If glass tubes break, remove the glass, wearing proper personal protective equipment, very carefully from the adapters, buckets, or rotor cavities. Examine and clean the gasket and/or chamber bowl with care because glass fragments may have become embedded in them.
- Dispose of all waste solutions according to the University's Hazardous Waste Disposal plan.

6. Electrical Safety

- Any servicing of this equipment that requires removal of covers can expose parts, which involve the risk of electric shock or personal injury. Make sure that the power switch is turned off and the centrifuge is disconnected from the main power source, locked out and tagged. Only a qualified representative from the centrifuge company shall perform maintenance operations.
- To reduce the risk of electrical shock, the centrifuge uses a three-wire electrical cord and plug to connect the equipment to earth-ground.
- Make sure that the matching wall outlet receptacle is properly wired and earth-grounded.
- Check that the line voltage agrees with the voltage listed on the name rating plate affixed to the centrifuge or provided in the centrifuge pre-installation requirements.
- Never use a three to two plug adapter with bench top centrifuges.
- Never use a two-wire extension cord or a two-wire grounding type of multiple outlet receptacle strip with bench top centrifuges.

AA. Rotary Evaporators

Glass components of the rotary evaporator should be made of Pyrex or similar glass. Glass vessels should be completely enclosed in a shield to guard against flying glass should the components implode. Increase in rotation speed and application of vacuum to the flask whose solvent is to be evaporated must be gradual.

Safe operation of rotary evaporator operation involves the mitigation of the hazards associated with implosions, explosions, and solvents.

1. Implosion Hazard

- Use only glassware that is free from cracks and imperfections.
- Use heavy-walled vacuum flasks.
- Use shatter-proof collection bulb.
- Use safety netting around the condenser.

2. Explosion Hazard

- Compounds such as azides and peroxides are thermally unstable and must not be isolated via a rotary evaporation unit.
- Laboratory personnel must investigate the properties of the compounds prior to isolation.
- Ethereal solvents can form peroxides when exposed to air and light over time. Evaporation of these types of solvents will concentrate the peroxides which may can a very violent explosion.

3. Solvent Hazard

- Large amounts of organic solvent vapor can be generated during the evaporation. The collection bulb and condenser must be cooled to minimize solvent loss into the vacuum system.
- The cooling trap prevents hazardous solvent vapors from entering the vacuum system. It protects the pump and the piping from the potentially damaging effects of the material. It protects the maintenance personnel who may have to work on the system.

BB. Laboratory Doors

Laboratory doors must be closed at all times as required by the Philadelphia Fire Code. Closed laboratory doors maintain the required fire resistance rating as well as the negative pressurization of the laboratory. The rating and pressurization are necessary to prevent chemical vapors, fire, and smoke from spreading into other portion of the building. Propping the door open for extend periods of time eliminates the fire-resistant rating and disrupts the negative containment within the laboratory allowing chemical vapors, fire and smoke to spread in the event of an emergency. The loss of the negative pressurization and its effect on the air flow of the laboratory by leaving the doors open also reduces the efficiency of the chemical fume hoods and biological safety cabinets in the laboratory.

Since doors obviously serve as an exit from the lab space, it is important not to place obstructions near them so personnel can quickly exit in an emergency. Do not block lab door windowpanes with paper, lab coats, or other items. It helps the emergency and security personnel identify, notify and assist individuals in emergencies.

CC. Ethylene Oxide Sterilizers

The Drexel University Ethylene Oxide Exposure Through the Use of Sterilizers Protection Program is designed to protect employees whose duties require them to work in areas where the potential for ethylene oxide (EtO) exposure exists. The purpose of this program is to reduce and limit exposure to EtO using engineering and work practice controls. Due to the determination that EtO presents a carcinogenic,

mutagenic, genotoxic, reproductive, neurologic, and sensitization hazard to exposed workers, the OSHA created the Ethylene Oxide Standard, 29 CFR 1910.1047. The *Drexel University Ethylene Oxide Exposure Through the Use of Sterilizers Protection Program* complies with this standard. Please contact EHRS at ehrs@drexel.edu for further details regarding this program.

DD. Vacuum Systems

Vacuum pumps are used in the lab to remove air and other vapors from a vessel or manifold. The most common usages are on rotary evaporators, drying manifolds, centrifugal concentrators ("speedvacs"), acrylamide gel dryers, freeze dryers, vacuum ovens, tissue culture filter flasks and aspirators, desiccators, filtration apparatus and filter/degassing apparatus. Selection of a vacuum pump depends upon the type of application to be used, nature of the sample (air, chemical or moisture) and size of the sample.

When using a vacuum pump on a rotary evaporator, the collection bulb and condenser must be cooled to minimize solvent loss into the vacuum system. The cooling or cold trap prevents hazardous solvent vapors from entering the vacuum system. It protects the pump and the piping from the potentially damaging effects of the material. It protects the maintenance personnel who may have to work on the system.

Vacuum pumps can pump vapors from air, water to toxic and corrosive materials like TFA and methylene chloride. Oil seal pumps are susceptible to excessive amounts of solvent, corrosive acids and bases and excessive water vapors. Pump oil can be contaminated quite rapidly by solvent vapors and mists. Condensed solvents will thin the oil and diminish its lubricating properties, possibly seizing the pump motor. Corrosives can create sludge by breaking down the oil and cause overheating. Excess water can coagulate the oil and promotes corrosion within the pump. Proper trapping (cold trap, acid trap) and routine oil changes greatly extend the life of an oil seal vacuum. Pump oil should be changed when it begins to turn a dark brown color.

Diaphragm pumps are virtually impervious to attack from laboratory chemical vapors. They are susceptible to physical wearing of the membrane if excessive chemical vapors are allowed to condense and crystallize in the pumping chambers. A five-minute air purge either as part of the procedure or at day's end will drive off condensed water vapors further prolong pump life.

The exhaust from stand-alone vacuum pumps must be exhausted into the hazardous exhaust system to prevent exposures to hazardous chemical vapors. The pumps can be exhausted into the chemical fume hood or into a local exhaust snorkel. The pumps must not be placed into the chemical fume hood.

All processes utilizing the house vacuum system must be scrubbed prior to entering the main piping system. The overall purpose is to protect the system and personnel working on the system.

- Use a filter for particulate contaminants.
- Use a filter flask at room temperature of most aqueous and non-volatile liquids.
- Use a cold trap of sufficient size and cold enough to condense vapors generated followed by a filter flask capable of collecting fluid that could be aspirated out of the trap.

The use of cold and acid traps is essential but introduce other hazards associated with the trap contents (i.e. skin, inhalation and explosion hazards). Personnel must review and understand the risks associated with these types of traps.

EE. Chemical Fume Hoods

A well-designed chemical fume hood, when properly installed and maintained, offers a substantial degree of protection to the user, provided that it is used correctly and its limitations are understood.

The required face velocity for chemical fumes hoods at Drexel University ranges from 80-120 feet per minute (fpm) with an optimum face velocity of 100 fpm at a sash position of 18 inches. During use, the sash should be opened to 18 inches or less; each chemical fume hood is labeled to indicate this position. In the event that the face velocity of a chemical fume hood is below 80 fpm or above 120 fpm or the airflow monitor is alarming, contact Drexel EHRS at ehrs@drexel.edu. In this situation, the chemical fume hood must not be used until it is repaired and retested. The same guidelines apply to low-flow chemical fume hoods which have an acceptable range of 60 – 100 fpm.

When a chemical fume hood is not in use, the sash must be closed completely to provide the highest level of protection. This will reduce energy costs and help maintain comfortable conditions in the laboratory. In addition, the chemical fume hood must not be used as a storage area when not in use.

1. Chemical Fume Hood Limitations

A chemical fume hood is not designed to contain explosions unless specifically designed for this function. A chemical fume hood is not a pollution control device. All contaminants that are removed by the exhaust system are released directly into the atmosphere. Apparatus used in hoods must be fitted with condensers, traps, or scrubbers to contain and collect waste solvents or toxic vapors or dusts. A chemical fume hood must not be used for waste disposal. It is a violation of environmental regulations to intentionally evaporate hazardous chemicals in the chemical fume hood.

Ductless chemical fume hoods are prohibited at the university. These types of hoods use chemical absorbent filters to capture the vapors generated during the experiment and recirculate the air back into the laboratory. These filters are only designed for specific chemicals. The hood will not capture the vapor of chemicals outside the specification. The result is contaminated air recirculated into the laboratory space. In addition, the filters in the hood become saturated at some point depending on the hood usage. This requires the user to change the filters when this occurs. In most cases, the user never changes the filter and keeps using the hood. It is for these reasons ductless hoods are strictly prohibited.

2. Chemical Fume Hood Evaluations

Chemical fume hood performance evaluations are conducted annually by an outside contractor contracted through EHRS. Each chemical fume hood is labeled with an inspection sticker that displays the date that the hood was inspected, the measured face velocity, and the name of the inspector who conducted the test. Chemical fume hoods failing to pass the certification test are tagged out of service until repair and recertification. Laboratory personnel are instructed by EHRS not to use the chemical fume until the unit is recertified

3. Using Chemical Fume Hoods

Good laboratory practices must be employed while performing work in a chemical fume hood to facilitate adequate protection. Recommended practices are listed below.

- Use a chemical fume hood or other local ventilation device when working with hazardous chemicals. All work involving chemicals with high vapor pressure or low exposure limits must be always performed in a chemical fume hood.
- Design experiments in consideration of chemical fume hood space, air flow and the properties of the chemicals. Before beginning work, verify that the type of chemical fume hood to be used and the face velocity are appropriate for the chemicals involved and the procedure to be performed.
- Know the properties of the chemicals with which you work. Be able to identify signs and symptoms of overexposure.
- Prior to performing work in a chemical fume hood be sure the hood is exhausting properly. Verify that the reading from the continuous air flow monitoring device is no less than 80 fpm, no greater than 120 fpm, and within 20% of the face velocity value listed on the inspection sticker. If the reading differs significantly from that on the sticker, or if the unit is in alarm, the chemical fume hood may not be operating properly. If hood is not working properly immediately stop work and notify EHRS at 215-895-5919 or by email at ehrs@drexel.edu.
- Check areas around the chemical fume hood for sources of cross drafts that may cause turbulence and result in leaks from the hood into the laboratory.
- Ensure that the inspection sticker is current (within one year).
- Laboratory personnel must not lean into the hood so that his/her head is inside the plane of the hood face. The only exception is during experimental setup or hood maintenance.
- Do not block baffles. Visually inspect the baffles to be sure the slots are open and unobstructed.
- Avoid opening and closing the fume hood sash rapidly and avoid swift arm and body movements in front of or inside the hood. These actions may increase turbulence and reduce the effectiveness of fume hood containment.
- Place equipment as far to the back of the hood as practical without blocking the bottom baffle. Separate and elevate each instrument by using blocks or racks so that air can flow easily around all apparatus.
- Do not use large pieces of equipment in a hood, because they tend to cause dead spaces in the airflow and reduce the efficiency of the hood. If large pieces of equipment emit fumes or heat, then have a special purpose hood designed and installed to ventilate that particular device.
- Keep sash completely lowered anytime no “hands-on” part of an experiment is in progress. Close sash when finished with hood work or when leaving experiments or chemicals unattended. The hood sash must not be removed or left completely open except for setup work.
- Keep sash clean and clear.
- The hood sash must be closed to the lowest position possible while still allowing comfortable working conditions. EHS recommends the sash height be maintained at a distance from the bench top between **15” (fifteen inches)** and **18” (eighteen inches)**. This distance shall reduce the possibility of chemicals splashing eyes and face.
- Fume hoods must not be used for storage space with the exception of chemical waste containers ready for pick-up for disposal.
- All chemicals not being used for an experiment must be removed from the hood and placed in their proper storage area until needed.
- Drip pads in the hood must be replaced with new pads daily.
- Laboratory personnel must clean up all minor spills in the hood immediately. In the case of a major spill contact the Public Safety 24 Hour Call Center at 215-895-2222.
- All materials used to clean up spills must be discarded as hazardous waste.
- Clean all chemical residues from the hood chamber when finished with work.
- All electrical devices must be connected outside the hood to avoid sparks, which may ignite a flammable or explosive chemical.
- **Do not use a hood for any other function for which it was not intended**. Certain chemicals or reactions require specially constructed hoods. Do not manipulate any portion (e.g. alarm, side walls,

sash, pressure sensor, baffles, etc.) of the chemical fume hood. Do not drill holes into the side walls of the hood. **Do not disable the airflow monitor on the chemical fume hood**.

- The hood sash is not a substitute for personal protective equipment. Laboratory personnel must wear safety glasses, laboratory coat, and gloves at all times when working with chemicals in the hood.
- Do not **heat** perchloric acid in a conventional chemical fume hood. Perchloric acid is a very dangerous corrosive and oxidizing agent at high concentrations greater than 70% and at elevated temperatures. Heating perchloric acid generates concentrated vapors that will accumulate in ductwork and form perchlorate crystals that have the potential to explode, causing serious injury to personnel and damage to property. Room temperature concentrations of 70% or less are not significant oxidizers and tend not to generate perchloric acid crystals.
- Never turn off the chemical fume hood exhaust. The exhaust of the chemical fume hood is integral to the overall laboratory ventilation system. Shutting off the exhaust will drastically impact the ventilation efficiency and containment of the laboratory. If the desire is to save energy, then closing the sash on the hood is a good place to start.

4. Other Laboratory Exhaust Systems

Many laboratories use equipment that can generate airborne contaminants but cannot be used within a chemical fume hood. Examples include gas chromatographs, ovens, and vacuum pumps. Other types of local exhaust ventilation systems may be required to control contaminants generated by these operations. Such systems must have a separate exhaust duct and must not be installed without approval from EHRS. Consult EHRS before installing, modifying, or purchasing laboratory ventilation equipment to verify that it conforms to all relevant safety, building, and fire code regulations.

FF. Glove Boxes

A glove box is a sealed box used to manipulate materials where a separate atmosphere is desired. They are commonly used to protect laboratory personnel from hazardous materials or to protect chemicals or materials that are sensitive to air or water vapor.

Glove boxes may be used as positive pressure or negative pressure containment devices. Boxes operated under positive pressure usually contain materials sensitive to outside contaminants such as air or water vapor. Exposure to the outside atmosphere may lead to degradation or a violent reaction. Most positive pressurized glove boxes operate under an inert gas atmosphere. The gas used to create this atmosphere is usually nitrogen or argon. Negative pressure glove boxes are used to protect the laboratory personnel and are used for hazardous materials such as toxic gases or pathogens.

Laboratory personnel must adhere to the following measures when working with glove boxes:

- The PI must ensure all laboratory personnel are trained on the proper operation of the glove box. The training must be documented and uploaded to BioRAFT.
- Positive pressure glove boxes must have local exhaust ventilation for the box purge vent and the vacuum pump exhaust.
- Negative pressure glove boxes must have airflow alarms to ensure the box has exhaust airflow.
- Inspect the condition of the gloves on a daily basis. Check for holes, areas of discoloration, and the connection to the exterior.
- Inspect the condition of the windows on a daily basis. Pay specific attention to the areas where the window connects to the metal frame.

- Inspect the vacuum pump to ensure all lines are in good condition, the oil-mist filter is good, and the oil has been changed recently. Keep a log of the oil and filter changes.
- Inspect all pressure gauges and indicators to ensure proper function. Keep a log of the gauge settings for both positive and negative pressure glove boxes.
- If the glove box is equipped a solvent scrubber or solvent delivery system, ensure these components are working as designed.
- Maintain the maintenance schedule to ensure proper operation as per the manufacturer's specifications. EHRS recommends having a vendor under contract to provide this service.
- Ensure proper backup measures are in place for loss of power or loss of atmosphere.

Contact EHRS at ehrs@drexel.edu for additional information concerning glove box operations.

GG. Managing Chemical and Biohazard Spills

1. Preventing Spills

It is essential to preplan before working with hazardous chemicals, biologicals and radioactive materials. Get to know how to proceed with spill cleanup.

- Most spills are preventable. Place chemicals or other containers being used in a hood or bench area that reduces the possibility of accidentally knocking over a container.
- Keep the work area clean and free of clutter.
- Plan your movements. Look where you are reaching to ensure you will not cause a spill.
- Transport containers in a cart preferably using a secondary container.
- Place absorbent plastic backed liners on bench tops or in a fume hood where spills can be anticipated. If the volume inside a container is large, keep the container in a tray.

2. Laboratory Spill Procedures.

Immediately contact 911 or 215-895-2222 for all LIFE THREATENIGN INJURIES. In the event of a hazardous material spill the following procedures must be implemented:

a. Chemical Spills

Major Spill Procedure - a large spill that is greater than 500 grams, 500 milliliters, and any amount of acutely hazardous materials, select agents, hazardous gases, or mercury.

- Notify persons in the immediate area that a spill has occurred.
- Avoid breathing vapors, mists, or dust of the spilled material.
- If possible turn off all ignition sources, turn on chemical fume hood exhaust and open sash if spill is not in hood.
- Immediately implement personal decontamination procedures if contaminated with a hazardous substance prior to reporting spill.
- Evacuate room and close the door.
- Contact the Public Safety 24-hour Call Center at 215-895-2222.
- Provide the following information to the Dispatcher:
  - Name and call back number.
  - The location of the spill (building and room number).

  - Type of material spilled.
  - The amount of material spilled.
- Remain on or near the telephone until you have received instructions from the Public Safety or EHRS.

Minor Spill Procedures - a small spill that is less than 500 grams, 500 milliliters, and not acutely hazardous.

- Immediately implement personal decontamination procedures if contaminated with a hazardous substance prior to cleaning up the spill.
- Laboratory personnel are responsible for the containment and cleanup of all minor spills.
- Utilize the cleanup materials provided in the spill kit located in every laboratory.
- Personnel must wear appropriate personal protection equipment during the cleanup.
- All hazardous materials must be disposed as hazardous waste. Contact EHRS at ehrs@drexel.edu for disposal.

Refer to the University's Hazardous Material Emergency Response Plan for more details.

b. Blood or Other Potentially Infectious Materials (OPIM)

- All spills must be immediately contained and cleaned by appropriately trained personnel.
- Utilize Universal Precautions when cleaning blood or OPIM. Personnel must wear hand, eye and skin personal protection during the cleanup.
- Sharps are NOT to be picked up directly with the hands and shall be cleaned up using mechanical means. Dispose all sharps in an approved sharps container.
- Spray mist disinfectant over entire spill area. Do not pour or spray direct stream at the spill to prevent splashing and aerosolization of the material. Allow the disinfectant to remain in contact with contaminated area for the product manufacturer's recommended contact time or in the case of 10% bleach allow at least ten minutes.
- Wipe/sweep up using appropriate absorbent pads or towels.
- Place soiled absorbent in infectious waste bag.
- Repeat applying disinfectant over the entire area. Allow surface to air dry.
- Remove personal protection equipment. Dispose of gloves in infectious waste bag. Disinfect all non-disposable personal protection equipment and cleanup tools.
- Wash hands and arms.
- Contact EHRS for disposal of infectious waste.

Refer to the University Bloodborne Pathogen Control plan for specific details concerning cleanup of blood and other potentially infectious materials.

c. Radioactive Spills

Because any response depends upon the nature of the incident, radioactive spills have been categorized into minor and major spills.

Radioactive Minor Spills

If all the following are true, an incident can be considered minor:

- The nature and potential hazards are known

- There is no contamination of personnel
- One or two people can clean up the incident in about an hour
- There is no release of radioactive material into unrestricted areas
- There is no airborne radioactive material
    - There are no injuries (e.g., lacerations from broken glass) except where radioactive material is not involved and medical attention is not required
    - There is no potential uptake of radioactive material

In the event of a minor spill take the following steps:

- **Notify** all other persons in the room or area that a spill has occurred.
- **Prevent spread of contamination** by covering the spill with absorbent paper.
- **Decontaminate** the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
- **Survey** the area and all contaminated and potentially contaminated individuals with a G-M survey meter. Survey for removable contamination using wipe samples.
- **Report** the incident to EHRS by telephone.

Radioactive Major Spills

If any of the following are true, an incident should be considered major:

- The nature or potential hazard cannot be ascertained
- Personal contamination (skin or clothing; contamination of personal protective equipment, e.g., lab coats is not personal contamination)
- The cleanup will take more than two people or more than an hour to perform.
- There is a release of radioactive material into unrestricted areas.
- Airborne radioactive material is generated.
- Injuries which might involve radioactive material (e.g., laceration from contaminated glass)
- Injuries which require medical attention
- There exists the potential for an uptake of radioactive material.
- Fire or explosion
- Evacuation of the room or building is necessary

In the event of a major spill take the following steps:

- **Clear the area**: notify all persons not involved with or near the spill to vacate the room.
- **Prevent spread of contamination:** cover the spill with absorbent paper. Do NOT attempt to clean it up. Assemble all potentially contaminated personnel near the room entrance.
- **Close the room**: prevent entry into the room.
- **Call for help**: Immediately contact Radiation Safety.
- **Decontaminate personnel**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly with lukewarm water and then washed with mild soap and lukewarm water.

For more information on the university radiation safety program, consult the university's Radiation Safety Manual.

3. Personal Decontamination Procedures

Please be advised that these procedures are general decontamination procedures. These procedures might not be appropriate for certain types of hazardous materials. In effort to ensure proper decontamination consult the Safety Data Sheet prior to conducting any experiments. Implement **immediately if contaminated with a hazardous substance** prior to cleaning up or reporting spill:

For spills contacting the of skin, follow these procedures:

- Immediately flush with flowing water for no less than 15 minutes (i.e. sink or safety shower).
- If there is no visible burn, wash with warm water and soap, removing any jewelry to facilitate clearing of any residual material.
- Check the safety data sheet (SDS) to see if any delayed effects should be expected. If the SDS is not available contact the EHRS immediately at 215-895-5919.
- Seek medical attention for even minor chemical burns.
- Do not use creams, lotions, or salves.

For spills on clothing, follow these procedures:

- Do not attempt to wipe the clothes.
- Quickly activate the safety shower and remove all contaminated clothing, shoes, and jewelry.
- Seconds count, so do not waste time because of modesty
- Take care not to spread the chemical on the skin or, especially, in the eyes.
- Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes; it may be better to cut the garments off.
- Immediately flood the affected body area with warm water for no less than 15 minutes. Resume if pain returns.
- Get medical attention as soon as possible.
- Discard contaminated clothes as hazardous waste or have them laundered separately from other clothing.

For splashes into the eye, take these steps:

- Using the eyewash immediately flush for at least 15 minutes.
- Hold the eyelids away from the eyeball and move the eye up and down and sideways to wash thoroughly behind the eyelids.
- Get medical attention immediately. Follow first aid by prompt treatment by a member of a medical staff or an ophthalmologist who is acquainted with chemical injuries.

HH. Visitors and Minors

Unauthorized persons are prohibited from entering the laboratories and the animal facilities. Individuals who are immunosuppressed or whose immune system or ability to fight off infection may be impaired or not effectively working (e.g., people receiving treatment for cancer, people with asthma or received transplantation) and pregnant visitors are forbidden to enter research laboratories or animal facilities without the explicit permission from their physicians.

1. Visitors in Research Laboratories

The University benefits from the presence of many visitors and volunteers who come to the university for limited periods of time to participate in its research programs. These individuals may be given either salaried or non-salaried appointments for their research activities. Others wish to use the facilities of the University to engage in their own research or learn new research techniques. These individuals do not hold University appointments, do not provide services to the University, and may not receive compensation. They are instead designated as visiting scholars or visiting scientists. In addition, individuals who are members of the University community as students or employees may provide uncompensated volunteer services in research-related activities that are not part of their course of study or position at the University.

For the purpose of this guideline, a "visitor" is considered any person who enters a laboratory, clinic area, animal facility, or other potentially hazardous area upon the express or implied invitation of the site's director/supervisor. A "volunteer" is considered any person who, by his/her own decision, provides services to the University with no monetary or material compensation. We have an obligation to ensure that the activities of these visitors and volunteers are conducted in a safe manner. These individuals are subject to the same university policies as employees, as well as applicable federal, state, and local laws that may apply to their activities.

All visitors and volunteers must complete the appropriate online laboratory safety training modules provided through the EHRS website. These individuals must also read and comply with the University's Laboratory Safety Manual and Chemical Hygiene Plan. The Principal Investigator or the visitor's/volunteer's sponsor will be required to provide task-specific training in handling hazardous materials. The sponsor is responsible for assessing the individual's level of competence and providing further training as necessary.

There are several restrictions and approvals necessary for visitors and volunteers performing various types of work. The following restrictions and approvals are required where applicable:

- May not work with human subjects without the prior approval of the University's Institutional Review Board (IRB)
- May not work with patient records or protected health information without completing HIPAA training
- May not work with research animals without the prior approval of the University's Institutional Animal Care and Use Committee (IACUC)
- May not work with recombinant DNA or infectious agents without prior approval from the University Biosafety Committee – the individual should be listed as a visitor or volunteer on the protocol submitted by the sponsoring Principal Investigator

It is the responsibility of any person sponsoring a visitor or volunteer to ensure the individual understands and is compliant with the requirements contained in this guideline. It is also the sponsor's responsibility to ensure the laboratory/facility is in full compliance with all applicable university safety policies and procedures. In the event that the visitor/volunteer or the laboratory is not compliant with the requirements in this guideline, the visitor/volunteer may be removed from the laboratory and no longer granted permission to perform research activities in a Drexel lab. You may contact the Office of Research Compliance with any questions or concerns regarding the content of this guideline.
All visitors must complete, sign, and submit a Visitor Authorization form to the Department of Environmental Health and Radiation Safety prior entering or performing research activities in a university laboratory.

2. Minors in Research Laboratories

Minors often seek and acquire opportunities to study or work at the University and gain valuable knowledge and experience. We recognize both the importance of the educational and outreach missions of the university, and also the need to ensure a safe and healthy environment for all employees, students, and visitors. The following guideline pertains to the presence of minors in all University-based research laboratory settings or other work areas where potentially hazardous materials or conditions exist. For the purpose of this guideline, a minor is considered any individual under the age of 18.

No individual under the age of 16 may enter a university laboratory unless approved by the Department of Environmental Health and Radiation Safety, Risk Management and the Chair of the Department where the program will take place.

No individual between the ages of 16 and 18 may enter a laboratory or other work area with potentially hazardous conditions unless the minor is:

- An established University employee or student
- Part of a group or individual educational program approved in advance by the Department of Environmental Health and Radiation Safety, Risk Management and the Chair of the Department where the program will take place
- Part of a relationship in which a faculty member or researcher is acting as a mentor to the minor, the minor will not be present in the laboratory for more than two months, and all activities performed by the minor have been approved by the Department of Safety and Health

If a faculty member wishes to bring a minor into his/her laboratory for an educational program, the faculty member must:

- Contact the university's Minor Coordinator to get registered for managing minors on campus.
- Complete the following forms:
  - Request for Minor in Research Laboratories.
  - Informed Consent, Assumption of Risk and Release of Liability Form.
- Submit to the Chair of your Department, EHRS and Risk Management the request forms that provide the name and age of the student(s) and describes the educational intent of the proposed experience
- The Chair should review the request for educational appropriateness and forward a statement to EHRS and Risk Management that the proposed activity represents an approved educational program of the Department
- EHRS and Risk Management will evaluate the request for approval upon receiving the statement from the Chair of the Department.

Additional responsibilities for any faculty member planning to bring a minor into his/her laboratory include:

- Review the Guidelines for Minors in Research Laboratories and discuss the guideline with all minors that may be working in the laboratory
- Provide and document hazard specific safety training with the minor as approved by EHRS.
- Provide personal protective equipment, specific for any hazard, with instructions for proper use and disposal.
- Ensure the minor is supervised at all times while in the facility and never left alone.

- Ensure the laboratory/facility is in full compliance with all applicable university safety policies and regulations.

All minors are prohibited from working in the following laboratories or facilities:

- Any laboratory designated as Biosafety Level 3 (BSL-3)
- Any laboratory where select agents or explosives are used or stored
- Radioactive materials, radiation generating equipment (X-rays), or lasers
- Acutely toxic chemicals
- DEA Scheduled Drugs
- Pyrophoric Chemicals
- Hazardous Gases

II. Pregnancy Protection

The pregnant woman and her fetus are uniquely susceptible to the effects of ionizing radiation, toxic chemicals and infectious organisms, which may be present within the laboratory. Reproductive toxins are chemicals that can affect the reproductive system, including mutagens (chromosomal damage) and embryotoxins (harm the fertilized egg or fetus). Some chemicals may cross the placenta, exposing the fetus. A developing fetus may be more sensitive to some chemicals than its pregnant mother, particularly during the first twelve weeks of pregnancy, when the mother may not know she is pregnant. Proper handling of chemicals and use of protective equipment is especially important to reduce fetal exposure to chemicals. The period of greatest susceptibility is the first 8 - 12 weeks of pregnancy, which includes a period when a woman may not know she is pregnant.

Exposure to reproductive pathogens or other infectious materials cause immediate health risk to pregnant women. The EHRS and the investigator may review work procedures to ensure that potential exposure is minimized. Consideration maybe given for reassignment to other asks that does not involve exposure to reproductive hazards.

Laboratory workers who are contemplating pregnancy or are pregnant should review the toxicity of the chemicals in their laboratory and may consult EHRS to determine whether any of the materials used in the laboratory pose additional risk during pregnancy. EHRS provides confidential counseling to help determine what actions are recommended.

The following precautions should be taken:

- Pregnant women have the right to declare their pregnancy. If the pregnant woman who works with radioactive material chooses to declare her pregnancy, the Drexel University's Radiation safety office should be notified as soon as possible. Radiation exposure limits for women whom declared their pregnancy are 1/10th those allowed for the average laboratory worker. See the Drexel University's radiation safety guide for specific procedures.
- Women of childbearing age who are considering becoming pregnant or who may be pregnant should, if at all possible, avoid exposure to known teratogens (embryo toxins), mutagens, carcinogens and infectious agents. Commonly used laboratory teratogens include formamide, organo-mercurials, lead compounds and anesthetic agents (additional reproductive hazards are listed in the chemical safety portion of this manual). Exposure reduction/elimination can be achieved through reassignment, engineering controls, administrative requirements and as a last resort, the use of additional personal protective equipment.

- If you are pregnant or planning a pregnancy, you should discuss your work with your physician to determine any additional precautions that should be observed. If your duties require you to work with infectious agents, you must consider all possible consequences to yourself and your child. Special note: NIH Publication 73-439 recommends that pregnant women are not to be employed in a laboratory, which conducts studies on infectious viruses.
- Pregnant women may consider the following protocol in an effort to reduce the potential risks:
  - Declare your pregnancy through EHRS and the Radiation Safety Office;
  - Request a meeting with a university's safety representative, your PI and Radiation Safety Officer to discuss all possible options;
  - Review all options with you doctor and
  - Notify your PI, EHRS, and radiation safety of your decision as soon as possible so that proper procedures are implemented in an expeditious manner.

JJ. Emergency Response

1. Life Threatening Injury or Illness

In the case of a life-threatening injury or illness call 911 immediately and then contact Drexel Public Safety 24 Hour Call Center at 215-895-2222. The operator will notify security and the emergency response team who will perform rescue procedures and/or transfer the victim to the nearest emergency room. When speaking to the emergency operator state your name, location and the nature of the incident.

2. Non-life Threatening Injury or Illness

For all non-life-threatening injury or illness, immediately contact your principal investigator or laboratory supervisor. Contact Drexel Public Safety 24 Hour Call Center at 215-895-2222 to report the injury. Provide the dispatcher your name, description of the incident, and the exact location of the incident.

Employees must seek medical treatment, if necessary, at Concentra Occupational health during normal hours of 8 am to 5 pm Monday through Friday. The locations are:

Service Provider	Address
Concentra Occupational Health Center City	219 North Broad Street, Philadelphia, PA 19107 1st Floor 215-762-8525
Concentra Occupational Health Navy Yard	4050 S. 26th Street, Philadelphia, PA 19112 215-467-5800

Your supervisor can contact Concentra Occupational Health to arrange transportation to the one of the above locations. Employees should report to the nearest emergency room if the injury occurs outside the normal hours of operation or during an observed holiday.

The injured employee is required to report the incident immediately to their supervisor and EHRS.

Employees must complete an **employee injury report** and submit it to EHRS. This form must be submitted within 48 hours after the incident. If the injured employee is unable to complete the form within this time frame, his/her supervisor should obtain as much information about the accident as possible and submit the required form(s).

Employees must complete the **Worker Compensation forms** within 24 hours of the incident and forward the forms to the Office of Risk Management.

Students should seek medical treatment with his or her family physician, student health or closest emergency room with the exception of needle sticks. Students who suffered a needle stick can report to the University's Occupational Health Office (Concentra Occupational Health), student health or the closest emergency room for needle stick injuries. Students should complete the **student injury form** and submit it to **EHRS**.

3. Exposures

Always seek medical attention when exposed to hazardous materials.

- Eyes – Immediately flush eye(s) for a minimum of 15 to 20 minutes using the eyewash station.
- Face, Eye(s), and/or Body – immediately flush for a minimum of 15 to 20 minutes using the safety shower. Remove contaminated clothing while flushing.
- Hand(s) – immediately flush for a minimum of 15 to 20 minutes using the sink. If injected with an infectious needle utilize soap and water.
- Ingestion and inhalation – seek medical attention immediately.

KK. Hazardous Waste Management

The Hazardous Waste Management plan is updated annually and can be download on the EHRS website.

1. Hazardous Waste

Hazardous waste includes substances that are solids, liquids and gases. The EPA definition of hazardous waste includes substances that possess a hazardous characteristic (e.g. toxic, ignitable, corrosive or reactive with other substances), or substances that are listed as hazardous waste by the EPA on the basis of their usage or chemical constituents.

2. Hazardous Waste Identification

EHRS will perform identification of hazardous wastes. Since the majority of chemicals used in our facility are reagent grade the identification will be performed using Safety Data Sheets, bottle labels, and 40 CFR Part 261 Subpart B, C, and D. A third-party contractor will test for the ignitability, cross-reactivity, reactivity, and toxicity of unknown hazardous wastes.

3. Mixed Chemical Waste

EHRS shall require that only compatible chemical waste be combined into one waste container. Refer to the SDS for chemical compatibility or contact EHRS at ehrs@drexel.edu for assistance.

4. Multi-Hazardous Waste

Multi-Hazardous waste is waste that contains any combination of chemical, radioactive, or biological hazards. Any waste stream that presents more than one type of hazard will require special management

consideration because the selected treatment technology appropriate for one type of waste may not be appropriate for the other types. Multi-hazardous waste will be evaluated on an individual basis and the constituent that poses the greatest hazard will be given priority. Please contact EHRS at ehrs@drexel.edu for further instructions.

5. Drain Disposal

EHRS will permit drain disposal of elementary neutralized (pH adjustment of waste that are hazardous only because they exhibit the cross-reactivity characteristic) acidic aqueous solutions. The elementary neutralized aqueous solution must have a final pH value between 6 and 8. **The limit of material that may be neutralized is 1 liter**. EHRS will also permit drain disposal of common salts, sugars and agars in both liquid and solid forms. For solids, the material must be dissolved in tap water. The limit of material that may be disposed is 1kg of solid or 1 liter of liquid per day. EHRS prohibits the drain disposal of the following:

- Flammable or explosive pollutants
- Pollutants that will cause corrosive structural damage to the Publicly Owned Treatment Works (POTW), but in no case discharges with pH lower than 5.0.
- Solid or viscous pollutants that may cause an obstruction of flow in the POTW
- Pollutants capable of releasing fumes or vapors
- Pollutants, including oxygen-demanding pollutants (high biological oxygen demand), which may cause interference with the POTW
- Waste water with sufficient heat to inhibit biological activity in the POTW (must not exceed 104 F at the POTW)
- Petroleum, oil, non-biodegradable cutting oil or products of mineral oil origin in
- amounts that will cause interference or pass through Organic chemicals
- Heavy metal solutions
- Nitric, hydrofluoric, perchloric, and chromic acid
- Toxic/Poisonous solids and liquids
- Pharmaceutical waste.

6. Satellite Accumulation Areas

A satellite accumulation area is an area at or near a process that generates chemical wastes. The area must be under the control of the operator of that process. EHRS designates each laboratory as a satellite accumulation area. The laboratory Principal Investigator, LSL, Chemical Hygiene Officer, is responsible for following the policies of EHRS regarding satellite accumulation areas.

a. Allowable Amount Accumulated

Laboratories may accumulate as much as 5 gallons of hazardous waste or one quart of acutely hazardous waste (immediately hazardous to life and health) in compatible containers at or near any point of generation.

b. Labeling

- All containers must be labeled with the complete chemical name of each primary component. Formulas, acronyms and abbreviations are not acceptable.
- If possible, the label should include the approximate percentage of each chemical.

- Do not place the date or the words "Hazardous Waste" on the container. EHRS will re-label the container during pick-up as either a recyclable/re-distributable material or as hazardous waste at which time the container will be dated and moved to the temporary storage vault.

c. Container Types

There is a wide selection of biohazard containers. All containers must be kept closed except when it is necessary to add. Consult a Safety Data Sheet (SDS) to find specific information about chemical properties and compatibility. EHRS provides some containers made of plastic. Contact EHRS at ehrs@drexel.edu for additional information on the selection, use and obtaining containers.

d. Accumulation Time

There will be no limit on accumulation time; however, once a container is full or more than 5 gallons of hazardous waste or 1 quart of acutely hazardous waste is accumulated, the full container or excess waste must be moved to the accumulation area within 72 hours.

e. Inspection

Inspection of each satellite accumulation area shall be the responsibility of the principal investigator.

7. Chemical Pick-up Request

EHRS has an online chemical pick-up request form. This form should be immediately filled out when:

- Unwanted and old chemical reagents need to be removed.
- The satellite accumulation waste container is full.
- There is more than 5 gallons of hazardous waste or one quart of acutely hazardous waste accumulated.

Laboratory personnel can submit chemical pick-up requests electronically to EHRS. The request must be completely filled out with the requested information. Once the request is submitted a return email is sent to confirm the request. Personnel from EHRS will respond to chemical pick-up request within 72 hours of receipt of request. Unknown chemicals will not be removed from the laboratory.

8. Radioactive waste

Radioactive waste shall be collected and disposed in accordance with the Radiation Safety Manual. Researchers can contact radiation safety at ehrs@drexel.edu.

9. Regulated Medical Waste

Regulated Medical Waste, which includes infectious and biohazardous wastes, shall be disposed in accordance with the requirements set forth by the University's Hazardous Waste Management Plan. Please refer to regulated medical waste disposal in this manual for detailed instructions on the proper handling of regulated medical waste.

10. Pharmaceutical Compounds

a. DEA Scheduled Controlled Substances

DEA Scheduled pharmaceutical compounds must be disposed in accordance with DEA policies and procedures for the destruction and disposal of scheduled substances. Individuals using such materials for research or clinical activities must be licensed to purchase, use and possess these items. For additional information on handling and stored refer to the DEA Diversion Control Regulations.

The following procedure establishes specific procedures for disposal of DEA Schedule II, III, IV and V controlled substances. This procedure does not cover Schedule I controlled substances. This procedure provides research and clinical personnel assistance with disposing of unwanted or expired controlled substances in a safe and controlled manner. Schedule I drugs will be handled on a case by case basis.

Disposal Procedures for Registrants

1. Submit a chemical pick-up request to EHRS.
2. Complete and submit the online chemical pickup request form indicating the contact information, controlled substance name with DEA schedule number, state, hazard classification (controlled substance), container type, number of containers and total weight/volume of material.
3. The request system will send an automated email to the requestor upon submission. The request system records the date and time of submission.
4. Upon receiving the request EHRS will electronically send the requestor within 72 hours the Request for Incineration Forms from Stericycle Environmental Services.
5. The requestor must complete the forms including registrant name, DEA registration number, number of packages, package size, substance name, strength, NDC Number, and DEA Schedule. The requestor submits the form to the Hazardous Materials Manager at ehrs@drexel.edu along with a copy of their current DEA registration.
6. EHRS will send the completed form and copy of the researcher's current registration to Stericycle Environmental Solutions for DEA approval. The approval process usually takes two weeks.
7. Upon DEA approval, Stericycle Environmental Services will provide EHRS a date for pick-up and disposal.
8. EHRS will notify the requestor the date of pick-up. The registrant must be present during the pick-up of the substance or substances.
9. **The Department of Environmental Health and Radiation Safety is not permitted to take possession, handle or destroy control substances**.

Disposal for Non-Registrants or Expired Registrants

1. All non-registered personnel in possession of a controlled substance may request assistance by submitting a letter to the Special Agent in Charge of the Administration in the area in which the person is located for authority and instructions to dispose such substances.
2. The Special Agent in Charge can be determined by contacting the local area DEA office. The locations can be found at http://www.deadiversion.usdoj.gov/offices_n_dirs/index.html.
3. The letter must state the following:
   - Name and address of the requestor.
   - Name and quantity of each controlled substance to be disposed.
   - How the requestor obtained the substance, if known; and
   - Name, address, and registration number, if known, of the person who possessed the controlled substance prior to the requestor, if known.

4. The Special Agent in Charge will authorize and instruct the requestor to dispose the controlled substance in one of the following manners:
   - Transfer to person registered under the Act and authorized to possess the substance.
   - Deliver to an agent of the Administration or to the nearest office of the Administration.
   - Destroy the substance in the presence of an agent of the Administration or other authorized person; or
   - By such other means as the Special Agent in Charge may determine to assure that the substance does not become available to unauthorized persons.
5. **Please remember the Special Agent in Charge can only authorize disposal. EHRS is not permitted to take possession, handle or destroy controlled substances.**

Recordkeeping

- EHRS will scan and maintain all transfer paperwork for disposals associated with current DEA Registrants.
  - A copy of the destruction manifest from Stericycle Environmental Solutions will be stored on the department's shared drive. An electronic copy of the destruction manifest will be sent to the requestor for recordkeeping.
  - EHRS will maintain all records for period of five years.
- All non-registered requestors should keep all records of the correspondence to the Special Agent in Charge and any disposal documents.

b. Non-Schedule Pharmaceutical Materials

Pharmaceuticals which contain P, U, or D listed, and DEA regulated substances may not be disposed by this process. A third-party vendor has been contracted to dispose non-hazardous pharmaceutical materials. If you require assistance disposing listed pharmaceuticals or DEA regulated materials, please contact EHRS at ehrs@drexel.edu.

EHRS provides blue ten (10) gallon containers to each work area for the disposal of non-regulated pharmaceutical materials. The laboratories are to utilize these containers to dispose their non-regulated pharmaceuticals. These containers are only for the collection of non-hazardous pharmaceuticals. Biohazardous sharps and non-sharps waste may not be placed in these containers.

The University contractor will pick up the blue containers on an **as needed basis**. EHRS must be notified in order to schedule the requested pickups. Pickups will occur during normal business hours. Staff must be present at facility for pickups to occur. Contact EHRS at ehrs@drexel.edu if additional bins are needed.

11. Training

EHRS will provide training to all University employees/students who handle hazardous waste in laboratories. Each employee/student shall receive training on proper handling of chemicals and emergency response procedures. Initial training must be completed during the first month of employment (refresher training is provided annually thereafter). Hazardous waste training is provided through the BioRAFT compliance platform. Additional training sessions can be arranged by contacting EHRS at ehrs@drexel.edu. EHRS shall document all hazardous waste training. Training records will be kept for at least three years from the date the employee last worked at the university.

LL. Use of Earbuds and Headphones in the Laboratory

EHRS prohibits the use of earbuds and headphones in the laboratory. Earbuds and headphones can become contaminated with chemical, biological, or radioactive material. This cross contamination may provide a route of entry and put the laboratory member's health at risk. In addition, the use blocks the ambient noise and emergency notifications which puts the laboratory member at risk of an accident.

MM. Demonstrations

Demonstrations in non-laboratory spaces involving chemical, biological, radioactive, or physical agents must be reviewed by EHRS and Risk Management prior to the event.

Faculty members or teaching assistances performing demonstrations in laboratory spaces must conduct a risk assessment prior to the demonstration and submit the assessment to EHRS for review.

NN. Magnets

Superconducting magnets, such as Nuclear Magnetic Resonance (NMR), pose unique safety concerns. These concerns include cryogen safety, strong magnetic fields and the potential for creation of oxygen deficient atmospheres. The highest potential for the most serious of these hazards exists during magnet start-up, cryogen filling and maintenance activities. Once magnets are operational and magnetic fields have been established, the hazards are minimal as long as operators, maintenance personnel, and/or visitors understand the proximity limits and procedures to follow when working near the magnet.

1. Hazards

Ferromagnetic objects are strongly attracted to the magnet and can become potentially lethal projectiles. Personnel can be severely injured and/or equipment can be damaged if hit by objects that are attracted to the magnet at a high rate of speed. In the case of MRI units, life threatening situations can occur if a person is pinned against the magnet by a large ferromagnetic object. Absolutely no ferromagnetic objects are allowed inside a magnet room or within the pre-determined radius of the magnetic field.

Metallic implants and prostheses and foreign metallic bodies (even those which are not ferromagnetic) can move or dislodge, causing severe injury. Examples include aneurysm clips, implanted pins, shrapnel, insulin pumps, prosthetic limbs, cochlear implants, pacemakers, and cardiac or neural defibrillators.

Magnets generate strong electromagnetic fields and magnetic fields that can inhibit the operation of magnetically-sensitive equipment (certain implants or external devices), resulting in death or serious injury to the user. The most common item in this category is the cardiac pacemaker. Persons with pacemakers should be restricted to areas where the magnetic field is less than 5 Gauss.

Liquid helium and nitrogen are used to maintain the magnetic field in NMR systems. Both liquids are extremely cold (liquid helium -452°F, liquid nitrogen -320°F), colorless, and odorless. A sudden boil-off of cryogens and accompanying loss of magnetic field (called a "quench") poses a significant safety risk. During a system quench (deliberate or accidental), gases generated by the rapid boil-off of liquid helium and nitrogen must be vented outside, but there exists potential for gaseous helium and nitrogen to be released into the magnet room. These gases will appear as a dense white fog, and visibility may be obscured in the vapor cloud. The released gases displace oxygen in the air, and this can cause rapid asphyxiation and unconsciousness without warning.

The cryogenic gases are not flammable; however, the extreme cold that exists during and immediately after a quench may cause air to condense and create liquefied oxygen on surfaces. Any liquid dripping from cold surfaces should be presumed to be enriched oxygen and treated as a potential fire hazard.

Exposure of the magnet to intense heat (such as the conditions that exist during a serious structure fire) could cause the magnet to rupture violently if pressure relief devices fail. Cooling the magnet with water helps prevent the rapid venting of cryogens.

2. Safety Requirements

- NMR magnets must be located in areas with restricted access to the public.
- No workstations must be designed or placed within the 5-gauss field of a magnet. The 5-gauss line should not extend into public thoroughfares or building egress routes. Individuals must be able to enter and exit the room without passing through strong magnetic fields.
- Magnetic fields must remain within the limits of the room or occupied area realizing that normal wall, ceilings and floor materials do not block static magnetic fields. NMR type magnet strongest magnetic fields may occur at the bottom and top where shielding is less, which means that consideration must be given to occupied areas above and below the magnet.
- At least one magnetically compatible fire extinguisher must be mounted immediately external to magnet rooms.
- The magnet room must be large and high enough to accommodate the helium cloud resulting from a quench (loss of superconducting field). During a quench, one half of the helium volume (between 40 and 100 liters for most NMR magnets) will boil off and be violently ejected from the helium vent on top of the magnet within one minute. This vapor cloud will seek the highest point in the room as it warms and expands up to 700 times in volume. During the next few minutes the remaining helium will boil off. Nothing can be done to stop a magnet quench once it begins.
- An NMR magnet room should always be sized so the space between the ceiling and the level of seven feet in the room is large enough to contain the initial volume of helium gas released from a quench. There must be adequate exhaust ventilation in the room of at least 10 air changes per hour.
- Oxygen sensors with associated local alarms must be installed in magnet rooms where there exists the potential for asphyxiation. Alarms for oxygen monitors installed in the magnet rooms must activate when levels of oxygen are below 19.5%.
- NMR magnets in smaller rooms or in rooms with inadequate ventilation, helium vent pipes hard- ducted to the helium quench valve or automated exhaust fans tied to oxygen monitors must be installed.
- Supplemental ventilation, oxygen alarms and emergency procedures must be established when magnets are installed in below grade pits. These are particularly important for NMR magnets. Liquid nitrogen vapors will collect in low areas and expand to create an oxygen deficient environment. Because of this significant hazard only experienced personnel should be allowed in the room during start-up.
- Approved signage must be posted at all entrances to NMR magnet rooms prohibiting entry by unauthorized personnel and conspicuously warning of magnetic fields.
- A visible indicator demarcating the 5-gauss line should be installed after magnet start up. The indicator can be a temporary barrier or permanent floor marking.
- Laboratory personnel filling NMR magnets must wear the appropriate personnel protection equipment. The minimum personal protective equipment requirements are thermal gloves, face shield, safety glasses lab coats, closed top/toed shoes, and long pants.
- The PI must develop standard operating procedures for Dewar filling and transport, cryogen spills and clean-up, response to emergency alarms including oxygen sensor alarms and magnet quench.

- The PI must train all laboratory personnel regarding emergency procedures for magnet quench (catastrophic loss and discharge of coolant), causes and consequences of a quench, how to prevent quenching, actions and notifications in the event of a quench, and evacuation procedures. The training must be documented and uploaded to BioRAFT.

Contact EHRS at ehrs@drexel.edu for additional information concerning magnet safety procedures.

OO. Ergonomics

Musculoskeletal Disorders (MSDs) affect the muscles, nerves, blood vessels, ligaments and tendons. Workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury.

Ergonomics is the study of the physical and psychological demands of activities in relation to the physical and psychological capabilities and limitations of people. The goal of ergonomics is injury prevention as discomfort often leads to pain and pain can lead to injury/illness. Ergonomics is the process of designing or arranging workplaces, products, and systems so that they fit the people who use them. Work-related MSDs can be prevented. Ergonomics helps lessen muscle fatigue, increases productivity, and reduces the number and severity of work-related MSDs. Examples of Musculoskeletal Disorders (MSDs) may include the following:

Cumulative Trauma Disorder (CTD) – An injury to the tissues, nerves, tendons, tendon sheaths and muscles (predominantly of the upper extremities) is the result of repeated forceful actions over a period of time. One or a combination of the following may cause CTD:

- Repetitive motion
- Forceful exertions
- Vibration
- Hard and sharp edges
- Sustained or awkward postures
- Exposures to noise over extended periods

Carpal Tunnel Syndrome (CTS) – A form of cumulative trauma disorders which affects one's hands and wrists. The symptoms are tingling, numbness, and severe pain in the wrist and/or hand, reduced hand strength and an inability to make a fist or hold objects. These problems are typically not noticeable until after work in the evening. The more advanced cases may result in permanent loss of sensation and partial paralysis of the hand and wrist.

Back Disorders – An injury to the back involving pulled/strained muscles, ligaments, tendons, and disks. Most result from chronic injury not a single incident. One or a combination of the following may cause back disorders:

- Excessive/repetitive twisting, bending, and or reaching
- Carrying, moving, and/or lifting loads that are either too heavy or too large
- Staying in one position for too long
- Poor physical condition
- Poor posture

- Prolonged sitting
- Back degeneration due to age
- Excessive activity without the benefit of prior physical conditioning
- Stress
- Vibration

To reduce the chance of injury, work tasks should be designed to limit exposure to ergonomic risk factors. Engineering controls are the most desirable, where possible. Administrative or work practice controls may be appropriate in some cases where engineering controls cannot be implemented or when different procedures are needed after implementation of the new engineering controls. Personal protection solutions have only limited effectiveness when dealing with ergonomic hazards.

1. Safe Lifting

Manual material handling (MMH) work contributes to a large percentage of the over half a million cases of musculoskeletal disorders reported annually in the United States. Manual handling refers to any activity requiring the use of force by a person to lift, lower, push, pull, hold, or restrain any animate or inanimate object. Manual handling may expose employees to physical conditions that can lead to cumulative trauma disorders or repetitive stress injuries. Utilize the following tips when lifting:

- Examine the load.
- Plan the lift.
- Wear appropriate clothing and shoes.
- Stretch.
- Use mechanical lifting devices.
- Use multiple people if mechanical lifting devices are not available.

The National Institute for Occupational Safety and Health (NIOSH) uses a 51-pound load constant to determine the maximum recommend load for a person to lift under ideal conditions. This 51-pound limit is a starting point, not an absolute safe weight. The recommended weight limit for a specific task is determined by several factors:

- The horizontal distance the load is from the lifter's body.
- The height of the load relative to the floor.
- The distance the load travels during the lift.
- The amount of twisting or bending of the torso during the lift.
- How often the lifting is performed within a certain time period.
- The quality of the hand-hold on the object.

All of these factors must be considered prior to manually lifting any materials/equipment to reduce the likelihood of injury. Avoid manually lifting loads that exceed the NIOSH 51-pound load constant. Utilize mechanical lifting devices or use multiple people to lift heavy or awkward materials.

Additional resources can be found on the EHRS Ergonomic website for manual material handling.

2. Laboratory Ergonomics

Laboratories provide many opportunities for ergonomic stressors to manifest into injuries or repetitive stress disorders. Major ergonomic issues in the laboratory setting includes static and/or awkward postures and repetitive motions. Use the following information to help mitigate these stressors.

Be Aware of Your Posture

- Sit against the back of your chair. If you sit back and your feet dangle, lower the chair or adjust the foot ring or get a footrest.
- Try tilting the seat forward or use a seat wedge to work in a forward posture without leaning or jutting your head forward.
- Always try to work at a bench cut out. Cut outs can help you get close to your work while sitting against the back of your chair.
- Don't jut your chin forward when working. Adjust the position of your work, the work surface, or the chair to sit in an upright, supported position.
- Keep frequently used trays and supplies within close reach.
- If standing for long periods, use supportive shoes and cushioned mats.

Keep Arms and Hands Relaxed

- Keep your shoulders relaxed and your elbows close to your sides when working. Avoid reaching out to use instruments and work materials.
- Maintain neutral or aligned wrist and arm postures when working. Sit close to your work area, keep objects close, and adjust your chair to match the height of the bench.
- Avoid repetitive or forceful twisting and turning motions (i.e. opening valves or adjusting microscopes). Make sure valves and knobs are clean and in good working order.
- Work with your wrist in a neutral or straight position as if you were shaking hands with someone.
- Use light pressure when performing tasks such as pipetting.
- Use electronic pipettes or light touch models whenever possible.
- Select equipment and tools that are the right size for your hand.
- Use padding and tubing to reduce pressure and force when working. For example, use rubber tubing on forceps.to increase diameter and reduce pinch force. Soften sharp edges on work surfaces with padding.
- Use thin, flexible gloves that fit properly. Ill-fitting and poorly designed gloves increase pinch and grip forces when working.

Avoid Static Positions

- Weight shift often when standing to work. Use a stool or shelf to prop up a foot to relieve pressure on your back.
- If standing in one spot for long periods, use cushioned floor mats or shoes with good support.
- Alternate how you hold objects like forceps. Switch holding with the thumb and index finger, and the index and middle fingers to vary the task.
- Vary activities. Change your position and take breaks every 20 minutes to rest muscles to rest and increase blood flow and circulation.

Additional resources can be found on the EHRS Ergonomic website for manual material handling.

3. Workstation Ergonomics

Incorporating ergonomics into your office will improve your productivity, make you more comfortable, and prevent stress and injury. Optimal workstation setup can be found on the EHRS Ergonomic website.

XII. Biological Safety

A. Introduction

This part of the manual provides a core set of biosafety practices and procedures for the safe handling of known biohazards and potentially infectious materials.

This part focuses mainly on Biosafety Levels 1 and 2, since many Drexel laboratories fall within these designations. A separate set of policies are available for researchers working in Biosafety Level 3 research laboratories. No work with Biosafety Level 4 agents is conducted at Drexel University.

The biological safety requirements for Drexel researchers are outlined in this part. Registration and training information are provided along with details on work practices, safety equipment and facility design. It is the responsibility of the Principal Investigator and/or Supervisor to ensure that his/her laboratory is in compliance. That responsibility includes identification of the risk or hazards associated with their research and the application of the appropriate safety procedures. Please read the section on responsibilities for additional information.

We urge you to use the manual as a road map to compliance within your laboratory. Consult the sections relevant to your research and apply the appropriate safety procedures. EHRS is available for consultation if you have any questions or concern with any aspect of the Biosafety Program at the University. The Occupational Health and Safety training credo, "Think before you act," and "If you do not know, ask," are relevant to the use of this manual. If you are unsure of a requirement or biosafety practice, please contact the EHRS at ehrs@drexel.edu for assistance. We also would appreciate any feedback or comments that you may have with Biological Safety and control of health hazards related to biological agents within the University community.

These Biosafety Guidelines have been established to protect the health and safety of students, faculty and staff, and meet regulatory requirements that are required by Occupational safety and Health Administration (OSHA), the Centers for Disease Control (CDC) and Prevention, and the National Institutes of Health (NIH). This manual has been prepared to provide guidance to work with potentially hazardous microbial agents, animals and other hazardous biologicals recombinant DNA molecules and the proper use of biological safety cabinets and laminar flow hoods.

B. Responsibilities

1. Deans, Directors and Department Chairpersons

The Dean, Director or Chairperson bears overall responsibility for the implementation and maintenance of safe practices and procedures in the department. The Chairperson, especially in the case of large departments, may share this responsibility with the unit head.

2. Principal Investigator

- Performing appropriate risk assessment of research projects. The level of detail should be dependent on the hazard associated with the organism under study (e.g., an assessment of risk associated with research on BL2 agents might reasonably be less detailed than a risk assessment of BL3 or unknown agents).
- Each evaluation should be completed before work is undertaken and the project should be reassessed periodically as new data is obtained.
- Assessment should include an analysis of the risks posed by the particular organism under investigation and by any specific research methods that may affect that risk (e.g., procedures requiring highly concentrated amounts of virus or inoculation of laboratory animals).
- No human or animal pathogen should be studied without prior written approval of the UBSC.
- The procedures for handling unclassified agents should be addressed by the UBSC and the EHRS.
- Information about these agents must be provided to the EHRS
- Applying appropriate safety practices and procedures within the laboratories and instructing students and staff of potential hazards.
- Approving research personnel to work in the laboratory and assuring that personnel are competent and trained to conduct the work.
- Developing policies governing the operation of the laboratory and implementing protocols to ensure safe operation.
- Maintaining liaison with the Biosafety Office and EHRS.
- Registering research work involving recombinant DNA, human and/or animal pathogens, etc. with the UBSC. The registration process can be access on the Biosafety Committee website. The registration application must have details of the nature of the proposed experiments and an assessment of the levels of physical and biological containment required for the experiments as established by the NIH guidelines.
- Responsible for ensuring that the reporting requirements are fulfilled and will be held accountable for any reporting lapses. The PI may delegate such reporting functions to EHRS with written notification to the NIH OBA of the delegation and of the name(s), address, telephone, and fax numbers of the contact.

3. Research Personnel

- Complete requirements for approval to work in the laboratory and ensure that all work is conducted in compliance with Drexel University, NIH, CDC, OSHA and other applicable regulations and guidelines. Follow the Drexel University Biological Safety Guidelines except where superseded by the *BL3 Manual* or the *Bloodborne Pathogens Exposure Control Plan.*
- Learn the operating procedures for the laboratory, the potential hazards of the infectious agents in use and emergency procedures. Help maintain the facility in good working condition.
- Report to the Principal Investigator any medical restrictions, reportable illnesses, and any event that may be an exposure or result in the creation of a potential hazard. Report all irregular conditions.
- If inexperienced in handling human pathogens or tissue cultures, receive training and demonstrate proficiency in standard microbiological practices from the Principal Investigator.
- Complete appropriate medical surveillance requirements.
- Perform assigned responsibilities. The operation of the laboratory is the responsibility of the users; therefore, a number of tasks must be assigned. These tasks are as follows:

    - Training
    - Autoclaves and waste

- Freezers
- Cleaning
- Vacuum trap and filter maintenance
- Maintenance of supplies, including personnel protective equipment
- Security of infectious agents; i.e. store infectious agents in a locked freezer in a locked laboratory.

4. Biological Safety and Recombinant DNA Officer

The Biosafety officer (BSO) is responsible for the implementation of the policy recommended by the Drexel University UBSC. The BSO identifies potential problem areas and suggests to the UBSC safety objectives to be achieved. The BSO for the University is the Director of EHRS.

In addition, as mandated by the NIH Guidelines for Research Involving Recombinant DNA Molecules, the University has appointed a Recombinant DNA Officer (RDO). The RDO for the University is the Co-chair of UBSC. The responsibilities of the BSO and the RDO are as follows:

- Ensuring through periodic inspections that laboratory standards are rigorously followed.
- Reporting to the UBSC and the Institutional Official or his/her designee all significant problems with and violations of the Guidelines and all significant research-related accidents and illnesses of which the BSO becomes aware unless the BSO determines that the Principal Investigator has done so.
- Identifying and updating of areas of known and potential biohazard at the University on a regular basis.
- Maintaining training records for compliance with federal, state and University requirements.
- Ensuring that each laboratory has emergency plans for dealing with accidental spills and personnel contamination and investigating research laboratory accidents involving rDNA research.
- Providing technical advice to members of the university community and IBC in matters related to biological safety.
- Providing advice on laboratory security.
- RDO will be providing periodic updates of rDNA experiments to ensure compliance with the NIH *Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines)*.

5. University Biosafety Committee

The University Biological Safety Committee (UBSC) shall serve as the Institutional Biohazards Committee (IBC) as defined in the National Institutes of Health (NIH) *Guidelines for Research Involving Recombinant DNA Molecules (NIH Guidelines).* As such, the Committee shall review applications for research involving recombinant DNA to determine whether the facilities, procedures, and practices meet the standards required by the University and the NIH. It shall, in addition, have the responsibility to certify annually to the NIH that such facilities, procedures, and practices, and the training and expertise of personnel meet NIH standards. Meetings called for the purpose of such review and certification may be open to the public. Minutes of these meetings shall be kept and made available for public inspection.

In addition, the UBSC also serves as the committee to review and approve the use of toxic chemicals and carcinogenic agents used in research laboratories. The committee's responsibilities include:

- Registering laboratories and approving containment and procedures to be used.
- Advising facility users on policies related to biohazard containment.
- Updating laboratory registrations periodically.
- Determining the necessity for special medical monitoring.
- Advising the university on the suspension of access privileges for staff found to be in violation of policies and procedures governing facility use.

- The UBSC shall advise the Senior Vice Provost for Research and Director of EHRS on policy matters concerned with the protection of personnel from biohazardous, agents including both infectious organism, allergens toxic chemicals and carcinogenic agents that may be present in laboratories.
- The Committee shall also recommend guidelines relating to procedures and facilities used at the University, including such matters as safety training and health surveillance.
- The Committee shall offer its counsel to all University personnel regarding matters of biological safety.
- The Committee shall meet regularly with the Director of the EHRS and the Biological Safety Officer to receive progress reports and advise on specific safety issues as well as on general safety policy.
- On matters of oversight that involve the evaluation of performance by the Biosafety Office, the Committee may, at the discretion of the chair, meet in executive session. In such cases the BSO and the Director of the EHRS shall be excused from participation and voting.

C. Safe Biosafety Laboratory Practices

- Always wear eye protection. For routine work, prescription glasses with tempered lenses and side shields or plastic safety glasses / goggles are acceptable.
- Wear other required personal protective equipment (PPE).
- Familiarize yourself with the location of safety equipment in the lab (e. g., eye wash station, shower, sinks, fire extinguisher, BSC, etc.)
- Avoid loose fitting items of clothing and wear appropriate shoes
- Change gloves when contaminated, and dispose used gloves with other contaminated laboratory waste.
- Treat all microorganisms as potential pathogens.
- Disinfect work areas before and after use with 70% ethanol or 10% bleach especially after spills. Complete disinfection takes approximately 10- 30 minutes when 10% Clorox or Alicide is used.
- Label everything clearly with date.
- Replace caps on reagents, solution bottles and bacterial cultures. Do not open petri dishes in the open lab.
- Wash your hands after working with potentially hazardous materials and before leaving the laboratory.
- Do not eat, drink, smoke, handle contact lenses, apply cosmetics, or store food for human consumption in the laboratory.
- Follow the institutional policies regarding safe handling of sharps (i.e., needles, scalpels, pipettes, and broken glassware).
- Take care to minimize the creation of aerosols and/or splashes. Perform such procedures inside a BSC.
- Decontaminate all work surfaces before and after your experiments, and immediately after any spill or splash of potentially infectious material with an appropriate disinfectant.
- Clean laboratory equipment routinely, even if it is not contaminated.
- Decontaminate all potentially infectious materials before disposal.
- Dispose of all potentially infectious waste material in a biohazard bag. Dispose of all sharps in appropriate sharps containers.
- Report any incidents that may result in exposure to infectious materials to appropriate personnel (e.g., laboratory supervisor, safety officer).
- Never work in the laboratory alone.
- Never pipet by mouth.
- Use disinfectants in a water bath when incubating infectious material.
- Take extreme safety precautions when working with infectious human material
- Restrict the use of syringes and needles to those procedures for which there are no alternatives.

D. Routes of Biohazard Exposure

There are four main routes of exposure that one must try to avoid when working with biohazardous agents in the laboratory. These would include percutaneous injuries, inhaling infectious aerosols, exposure to mucous membranes, and ingestion.

1. Percutaneous Route

- Percutaneous injuries can result from needle sticks, cuts or abrasions from contaminated
- Sharp items. These exposures are particularly serious because of the potential for immediate entry of the agent into a normally sterile bloodstream. All sharps items should be handled and disposed of as noted in the Drexel University Hazardous Waste Management Plan.

2. Inhalation of Aerosols

Many laboratory procedures can cause the aerosolization of infectious agents. Some of these procedures include the use of vortexes, blenders and sonicators. Proper work practices must be implemented to minimize the aerosolization of all materials, especially those which are known to be transmitted by the aerosol route (e.g., Adenovirus, Vaccinia virus, *Mycobacterium tuberculosis*, etc.). Contact EHRS at ehrs@drexel.edu for more information about minimizing and containing aerosols in the laboratory.

3. Mucous Membrane

Exposure of mucous membranes to infectious agents can lead to occupationally acquired infections. Mucocutaneous exposures can result from splashes to the eyes, nose or mouth, or by inadvertent inoculation via contaminated hands. Face protection should always be used if there is a likelihood of splash or splatter.

4. Ingestion

Accidental ingestion of biohazardous materials can result from improper personal hygiene in the laboratory. Food and drink are prohibited in all areas of the laboratory in which work is conducted with potentially infectious materials. Hands must always be washed before leaving the laboratory, and immediately if visible contamination occurs.

5. Accidental Exposure Response

In the event of a hazardous biological exposure (i.e., face, and/or eye splash, cut or puncture with sharps, contact with non-intact skin), the following procedures must be implemented:

- Allow needle sticks and cuts to bleed, gently wash the area with continuous wash for 10 – 15 minutes.
- Splashes to the nose, mouth or skin, flush with water for 15 minutes at the nearest eyewash station.
- Seek immediate medical attention immediately.

In the case of a life-threatening injury or illness call 911 immediately then contact Drexel Public Safety 24 Hour Call Center at 215-895-2222. The operator will notify security and the emergency response team who will perform rescue procedures and/or transfer the victim to the nearest emergency room. When speaking to the emergency operator state your name, location and the nature of the incident.

For all non-life-threatening injury or illness, immediately contact your principal investigator or laboratory supervisor. Contact Drexel Public Safety 24 Hour Call Center at 215-895-2222 to report the injury. Provide the dispatcher your name, description of the incident, and the exact location of the incident.

Employees must seek medical treatment if necessary, at Concentra Occupational health during normal hours of 8 am to 5 pm Monday through Friday. The locations are:

Service Provider	Address
Concentra Occupational Health Center City	219 North Broad Street, Philadelphia, PA 19107 1st Floor 215-762-8525
Concentra Occupational Health Navy Yard	4050 S. 26th Street, Philadelphia, PA 19112 215-467-5800

Your supervisor can contact Concentra Occupational Health to arrange transportation to the one of the above locations. Employees should report to the nearest emergency room if the injury occurs outside the normal hours of operation or during an observed holiday.

The injured employee is required to report the incident immediately to their supervisor and EHRS.

Employees must complete an **employee injury report** and submit it to EHRS. This form must be submitted within 48 hours after the incident. If the injured employee is unable to complete the form within this time frame, his/her supervisor should obtain as much information about the accident as possible and submit the required form(s).

Employees must complete the **Workers Compensation forms** within 24 hours of the incident and forward the forms to the Office of Risk Management.

Students should seek medical treatment with his or her family physician, student health or closest emergency room with the exception of needle sticks. Students who suffered a needle stick can report to the University's Occupational Health Office (Concentra Occupational Health), student health or the closest emergency room for needle stick injuries. Students should complete the **student injury form** and submit it to **EHRS**.

Send the injury report to EHRS and to the University Biosafety Committee (UBSC), if the work is done on an UBSC-approved protocol.

Any accidents involving recombinant DNA must be reported to EHRS and UBSC within 30 days to meet institutional requirements prescribed by the NIH Guidelines for Research Involving Recombinant DNA Molecules.

E. Biohazardous Agents

Biohazardous materials are defined as materials of biological origin that have the capacity to produce deleterious effects on humans or animals. They include:

- Recombinant DNA molecules that are transferred into human research participants (human gene transfer).

- Recombinant DNA that is introduced into animals [transgenic animals].
- Synthetic DNA segments which are likely to yield a potentially harmful polynucleotide or polypeptide e.g., a toxin or pharmacologically active agent.
- Microorganisms where there is a deliberate transfer of a drug-resistant trait or of recombinant DNA containing genes for the biosynthesis of products potentially toxic for vertebrates.
- Microorganisms with high risk are classified as risk group 2 [RG-2] or RG-3 agents. RG-4 agents are not allowed on the University campus whether infectious or defective.
- Microorganisms where more than two-thirds of the DNA from RG-2 or RG-3 agents is cloned into other nonpathogenic agents.
- Biological products derived from RG-2 or RG-3 microorganisms.
- Clinical/medical waste e.g., diagnostic specimens, that are used in research and known or reasonably expected to contain pathogens classified as RG-2, RG-3, or RG-4 agents, and culture of more than 10 liters of a biological agent.
- Carcinogenic and cytotoxic agents.
- Human tissues, including cells and blood products that require standard universal precautions associated with bloodborne pathogens (provide a reference for universal precautions).

Basis for the Classification of Biohazardous Agents by Risk Group

Risk Group	Risk to individual and the community
RG-1	Agent that is not associated with disease in healthy adult humans.
RG-2	Agent that is associated with human disease which is rarely serious and for which preventive or therapeutic interventions are often available.
RG-3	Agent that is associated with serious or lethal human disease for which preventative or therapeutic interventions may be available (high individual risk but low community risk)
RG-4	Agent that is likely to cause serious or lethal human disease for which preventative or therapeutic interventions are not usually available (high individual risk and high community risk)

Examples of RG-1 agents include microorganisms like *Escherichia coli*-K12 or *Saccharomyces cerevisiae*. A comprehensive list of specific infectious agents is provided in Exhibit 1.

Knowing the RG of a biological agent is necessary to complete a biosafety risk assessment and helps in assigning the correct biosafety level for containment. In general, RG-2 agents are handled at BL-2, and RG-3 agents at BL-3. However, the use of certain RG-2 agents in large quantities might require BL-3 conditions, while some RG-3 agents (such as the HIV virus) may be safely manipulated at a BL-2 under certain conditions. It is also true that some RG-2 agents can be handled at a BL-1 level. For more information on risk assessment, contact EHRS at ehrs@drexel.edu.

F. Recombinant DNA Materials: Regulations and Guidelines

The NIH Guidelines for Research Involving Recombinant or synthetic Nucleic Acid Molecules contain procedures for the containment of Recombinant or synthetic Nucleic Acid Molecules. Synthetic nucleic acids are defined as molecules that a) are constructed by joining nucleic acid molecules and b) that can replicate nucleic acids. Nucleic acids include those that are chemically or otherwise modified or amplified but that can base pair with naturally occurring nucleic acid molecules. Or molecules that result from the

replication of those described under this definition. The Guidelines apply to all institutions that receive NIH funding for rDNA. Consequences of noncompliance include suspension, limitation, or termination of NIH funds for rDNA research at the institution, or a requirement for prior NIH approval of rDNA projects at the institution. The purpose of the guidelines is to specify safe handling practices and containment levels for rDNA molecules, organisms and viruses containing rDNA molecules, and transgenic animals. A complete description of the University's responsibilities can be found in Section IV-B of the NIH Guidelines).

The institution assures that all NIH-funded projects involving recombinant DNA techniques shall comply with the NIH Guidelines. The institution expects all investigators to comply with the standards and procedures set forth in NIH guidelines for any rDNA research conducted at the institution irrespective of the source of funding.

Protocols or proposals for non-exempt rDNA work are submitted to the UBSC for review prior to initiation. The Committee is responsible for review of rDNA experiments for compliance and for assessing the containment level, facilities, procedures, practices, and expertise and training of research personnel. UBSC results are communicated to the PI describing the containment level and any additional precautions. The UBSC will also periodically review rDNA research at the University to ensure that the University is in compliance with the NIH Guidelines.

The PI is ultimately responsible for compliance with the NIH Guidelines and for the safe conduct of rDNA experiments. S/he must perform an initial risk assessment for rDNA work and identify an appropriate containment level for the experiment. In addition, the PI must ensure that all personnel involved in the experiment are trained in safe working procedures. (A complete list of PI responsibilities can be found in Section IV-B-7 of the NIH Guidelines). Experiments that require UBSC approval may not be initiated or modified until approval has been obtained from Committee.

1. Experiments Covered by the NIH Guidelines

The NIH Guidelines describe six categories of experiments involving recombinant DNA:

- those that require Institutional Biosafety Committee (IBC) approval, RAC review, and NIH Director approval before initiation (see III-A);
- (ii) those that require NIH/OBA and Institutional Biosafety Committee approval before initiation (see III-B);
- those that require Institutional Biosafety Committee and Institutional Review Board approvals and RAC review before research participant enrollment (see III-C);
- those that require Institutional Biosafety Committee approval before initiation (see III-D);
- those that require Institutional Biosafety Committee notification simultaneous with initiation (see III-E), and
- those that are exempt from the NIH Guidelines (see III-F).

Note: If an experiment falls into Sections III-A, III-B, or III-C and one of the other sections, the rules pertaining to Sections III-A, III-B, or III-C shall be followed. If an experiment falls into Section III-F and into either Sections III-D or III-E as well, the experiment is considered exempt from the NIH Guidelines.

Any change in containment level, which is different from those specified in the NIH Guidelines, may not be initiated without the express approval of NIH/OBA (see NIH Guideline Section IV-C-1-b-(2) and its subsections, *Minor Actions*).

All laboratory personnel conducting rDNA experiments must complete the University-mandated rDNA training. Contact EHRS at ehrs@drexel.edu or the Office of Regulatory Research Compliance (215) 895-5894 for additional information. The NIH Guideline can be viewed or downloaded from the NIH website. The NIH website makes periodic updates to the website when guidelines are modified. Please make sure to visit this site often to follow any updates or amendments made to the guidelines.

2. List of Protocols that Require UBSC Approval Prior to Initiation

- **III-A-1:** Experiments considered as *Major Actions* under the *NIH Guidelines* cannot be initiated without submission of relevant information on the proposed experiment to the Office of Biotechnology Activities, National Institutes of Health, 6705 Rockledge Drive, Suite 750, MSC 7985, Bethesda, MD 20892-7985 (20817 for non-USPS mail),
- **III-A-1-a:** Deliberate Transfer of a drug trait to a microorganism not known to acquire it naturally (see Section V-B, *Footnotes and References of Sections I-IV*), if such acquisition could compromise the ability to control disease agents in humans, veterinary medicine, or agriculture, will be reviewed by the RAC.
- **III-B-1:** Cloning of DNA encoding molecules lethal to vertebrates at an LD 50 of <100ug/kg body weight.
- **III-B-2**: Experiments that have been Approved (under Section III-A-1-a) as Major Actions under the *NIH Guidelines*
- **III-C-1:** Experiments Involving the Deliberate Transfer of Recombinant or Synthetic Nucleic Acid Molecules, or DNA or RNA Derived from Recombinant or Synthetic Nucleic Acid Molecules, into One or More Human Research Participant.
- **III-D-1:** Experiments Using Risk Group 2, Risk Group 3, Risk Group 4, or Restricted Agents as Host-Vector Systems (See Section II-A, Risk Assessment). Please contact EHRS for assistance with risk assessment and for information on any agents that are not listed in the Classification.
- **III-D-1-a:** Experiments involving the introduction of recombinant or synthetic nucleic acid molecules into Risk Group 2 agents will usually be conducted at Biosafety Level (BL) 2 containment. Experiments with such agents will usually be conducted with whole animals at BL2 or BL2-N (Animals) containment.
- **III-D-1-b:** Experiments involving the introduction of recombinant or synthetic nucleic acid molecules into Risk Group 3 agents will usually be conducted at BL3 containment. Experiments with such agents will usually be conducted with whole animals at BL3 or BL3-N containment.
- **III-D-1-c:** Experiments involving the introduction of recombinant or synthetic nucleic acid molecules into Risk Group 4 agents shall be conducted at BL4 containment. Experiments with such agents shall be conducted with whole animals at BL4 or BL4-N containment.
- **III-D-1-d:** Containment conditions for experiments involving the introduction of recombinant or synthetic nucleic acid molecules into restricted agents shall be set on a case-by-case basis following NIH/OBA review. A U.S. Department of Agriculture - Animal and Plant Health Inspection Service (USDA/APHIS) permit is required for work with plant or animal pathogens (see Section V-G and V-M, *Footnotes and References of Sections I-IV*). Experiments with such agents shall be conducted with whole animals at BL4 or BL4-N containment
- **III-D-2:** Experiments in Which DNA From Risk Group 2, Risk Group 3, Risk Group 4, or Restricted Agents is Cloned into Nonpathogenic Prokaryotic or Lower Eukaryotic Host-Vect.
- **III-D-2-a:** Experiments in which DNA from Risk Group 2 or Risk Group 3 agents is transferred into nonpathogenic prokaryotes or lower eukaryotes may be performed under BL2 containment. Experiments in which DNA from Risk Group 4 agents are transferred into nonpathogenic prokaryotes or lower eukaryotes may be performed under BL2 containment after demonstration that only a totally and irreversibly defective fraction of the agent's genome is present in a given recombinant. In the

absence of such a demonstration, BL4 containment shall be used. The Institutional Biosafety Committee may approve the specific lowering of containment for particular experiments to BL1. Many experiments in this category are exempt from the *NIH Guidelines* (see III-F below, *Exempt Experiments*). Experiments involving the formation of recombinant or synthetic nucleic acid molecules for certain genes coding for molecules toxic for vertebrates require NIH/OBA approval (see III-B-1 above, *Experiments Involving the Cloning of Toxin Molecules with LD_{50} of Less than 100 Nanograms Per Kilogram Body Weight*) or shall be conducted under NIH specified conditions as described in Appendix F *Containment Conditions for Cloning of Genes Coding for the Biosynthesis of Molecules Toxic for Vertebrates* in the NIH Guidelines.

- **III-D-2-b:** Containment conditions for experiments in which DNA from restricted agents is transferred into nonpathogenic prokaryotes or lower eukaryotes shall be determined by NIH/OBA following a case-by-case review. (A U.S. Department of Agriculture permit is required for work with plant or animal pathogens.)
- **III-D-3: Experiments Involving the Use of Infectious DNA or RNA Viruses or Defective DNA or RNA Viruses in the Presence of Helper Virus in Tissue Culture Systems. Caution:** Special care should be used in the evaluation of containment levels for experiments which are likely to either enhance the pathogenicity (e.g., insertion of a host oncogene) or to extend the host range (e.g., introduction of novel control elements) of viral vectors under conditions that permit a productive infection. In such cases, serious consideration should be given to increasing physical containment by at least one level. **Note:** Recombinant or synthetic nucleic acid molecules or nucleic acid molecules derived therefrom, which contain less than two-thirds of the genome of any eukaryotic virus being considered identical are considered defective and may be used in the absence of helper under the conditions specified in III-E-1 below, *Experiments Involving the Formation of Recombinant or Synthetic Molecules Containing No More than Two-Thirds of the Genome of any Eukaryotic Virus*.
- **III-D-3-a:** Experiments involving the use of infectious or defective Risk Group 2 viruses (R*isk Group 2 Agents*) in the presence of helper virus may be conducted at BL2.
- **III-D-3-b:** Experiments involving the use of infectious or defective Risk Group 3 viruses (*Risk Group 3 (RG3) - Viruses and Prions*) in the presence of helper virus may be conducted at BL3.
- **III-D-3-c:** Experiments involving the use of infectious or defective Risk Group 4 viruses (see *Risk Group 4 (RG4) - Viral Agents*) in the presence of helper virus may be conducted at BL4.
- **III-D-3-d:** Experiments involving the use of infectious or defective restricted poxviruses in the presence of helper virus shall be determined on a case-by-case basis following NIH/OBA review. A U.S. Department of Agriculture permit is required for work with plant or animal pathogens.
- **III-D-3-e:** Experiments involving the use of infectious or defective viruses in the presence of helper virus which are not covered in III-D-3-a above through III-D-3-d may be conducted at BL1.
- **III-D-4: Experiments Involving Whole Animals -** This section covers experiments involving whole animals in which the animal's genome has been altered by stable introduction of recombinant or synthetic nucleic acid molecules, or nucleic acids derived therefrom, into the germ-line (transgenic animals) and experiments involving viable recombinant or synthetic nucleic acid molecule-modified microorganisms tested on whole animals. For the latter, other than viruses which are only vertically transmitted, the experiments may *not* be conducted at BL1-N containment. A minimum containment of BL2 or BL2-N is required. **Caution** - Special care should be used in the evaluation of containment conditions for some experiments with transgenic animals. For example, such experiments might lead to the creation of novel mechanisms or increased transmission of a recombinant pathogen or production of undesirable traits in the host animal. In such cases, serious consideration should be given to increasing the containment conditions.
- **III-D-4-a:** Recombinant or synthetic nucleic acid molecules, or DNA or RNA molecules derived therefrom, from any source except for greater than two-thirds of eukaryotic viral genome may be transferred to any non-human vertebrate or any invertebrate organism and propagated under conditions of physical containment comparable to BL1 or BL1-N and appropriate to the organism under study.

Animals that contain sequences from viral vectors, which do not lead to transmissible infection either directly or indirectly as a result of complementation or recombination in animals, may be propagated under conditions of physical containment comparable to BL1 or BL1-N and appropriate to the organism under study. Experiments involving the introduction of other sequences from eukaryotic viral genomes into animals are covered under III-D-4-b below, *Experiments Involving Whole Animals*. For experiments involving recombinant or synthetic nucleic acid molecule-modified Risk Groups 2, 3, 4, or restricted organisms. It is important that the investigator demonstrate that the fraction of the viral genome being utilized does not lead to productive infection. A U.S. Department of Agriculture permit is required for work with plant or animal pathogens.

- **III-D-4-b:** For experiments involving recombinant or synthetic nucleic acid molecules, or DNA or RNA derived therefrom, involving whole animals, including transgenic animals, and not covered by Section III-D-1 above, *Experiments Using Human or Animal Pathogens (Risk Group 2, Risk Group 3, Risk Group 4, or Restricted Agents as Host-Vector Systems)*, or Section III-D-4-a, the appropriate containment shall be determined by the Institutional Biosafety Committee.
- **III-D-4-c:** Exceptions under III-D-4, *Experiments Involving Whole Animals*
- **III-D-4-c-(1):** Experiments involving the generation of transgenic rodents that require BL1 containment are described under III-E-3 below, *Experiments Involving Transgenic Rodents*.
- **III-D-4-c-(2):** The purchase or transfer of transgenic rodents is exempt from the *NIH Guidelines* under III-F below, *Exempt Experiments*.
- **III-D-6:** Experiments Involving More than 10 Liters of Culture - Experiments considered as *Major Actions* under the *NIH Guidelines* cannot be initiated without submission of relevant information on the proposed experiment to the Office of Biotechnology Activities, National Institutes of Health, 6705 Rockledge Drive, Suite 750, MSC 7985, Bethesda, MD 20892-7985 (20817 for non-USPS mail), 301-496-9838, 301-496-9839 (fax), the publication of the proposal in the *Federal Register* for 15 days of comment, review by RAC, and specific approval by NIH. The containment conditions or stipulation requirements for such experiments will be recommended by RAC and set by NIH at the time of approval. Such experiments require Institutional Biosafety Committee approval before initiation. Drexel UBSC does not review human gene transfer experiments. University has contracted Western IRB (WIRB) to review protocols involving human gene transfers. Contact the Office of Research (215) 895-5849 for submitting a protocol involving human gene transfer experiments.
- **III-E-1: Experiments Involving the Formation of Recombinant or Synthetic Nucleic Acid Molecules Containing No More than Two-Thirds of the Genome of any Eukaryotic Virus -** Recombinant or synthetic nucleic acid molecules containing no more than two-thirds of the genome of any eukaryotic virus (all viruses from a single Family being considered identical may be propagated and maintained in cells in tissue culture using BL1 containment. For such experiments, it must be demonstrated that the cells lack helper virus for the specific Families of defective viruses being used. If helper virus is present, procedures specified under III-D-3 above, *Experiments Involving the Use of Infectious Animal or Plant DNA or RNA Viruses or Defective Animal or Plant DNA or RNA Viruses in the Presence of Helper Virus in Tissue Culture Systems*, should be used. The DNA may contain fragments of the genome of viruses from more than one Family, but each fragment shall be less than two-thirds of a genome.
- **III-E-2:** Low Risk rDNA Plant Experiments.
- **III-E-3: Experiments Involving Transgenic Rodents -** This section covers experiments involving the generation of rodents in which the animal's genome has been altered by stable introduction of recombinant or synthetic nucleic acid molecules, or nucleic acids derived therefrom, into the germ-line (transgenic rodents). Only experiments that require BL1 containment are covered under this section; experiments that require BL2, BL3, or BL4 containment are covered under III-D-4 above, *Experiments Involving Whole Animals*.
- **III-E-3-a:** Experiments involving the breeding of certain BL1 transgenic rodents are exempt under Section III-F, *Exempt Experiments.*

- **III-F: Exempt Experiments -** The following recombinant or synthetic nucleic acid molecules are exempt from the *NIH Guidelines* and registration with the Institutional Biosafety Committee is not required; however, other federal and state standards of biosafety may still apply to such research (for example, the Centers for Disease Control and Prevention (CDC)/NIH publication Biosafety in Microbiological and Biomedical Laboratories).
- **III-F-1**: Those synthetic nucleic acids that: (1) can neither replicate nor generate nucleic acids that can replicate in any living cell (e.g., oligonucleotides or other synthetic nucleic acids that do not contain an origin of replication or contain elements known to interact with either DNA or RNA polymerase), and (2) are not designed to integrate into DNA, and (3) do not produce a toxin that is lethal for vertebrates at an LD50 of less than 100 nanograms per kilogram body weight. If a synthetic nucleic acid is deliberately transferred into one or more human research participants and meets the criteria of Section III-C, it is not exempt under this Section.
- **III-F-2:** Those that are not in organisms, cells, or viruses and that have not been modified or manipulated (e.g., encapsulated into synthetic or natural vehicles) to render them capable of penetrating cellular membranes.
- **III-F-3:** Those that consist solely of the exact recombinant or synthetic nucleic acid sequence from a single source that exists contemporaneously in nature.
- **III-F-4:** Those that consist entirely of nucleic acids from a prokaryotic host, including its indigenous plasmids or viruses when propagated only in that host (or a closely related strain of the same species), or when transferred to another host by well-established physiological means.
- **III-F-5:** Those that consist entirely of nucleic acids from a eukaryotic host including its chloroplasts, mitochondria, or plasmids (but excluding viruses) when propagated only in that host (or a closely related strain of the same species).
- **III-F-6:** Those that consist entirely of DNA segments from different species that exchange DNA by known physiological processes, though one or more of the segments may be a synthetic equivalent. A list of such exchangers will be prepared and periodically revised by the NIH Director with advice of the RAC after appropriate notice and opportunity for public comment.
- **III-F-7:** Those genomic DNA molecules that have acquired a transposable element, provided the transposable element does not contain any recombinant and/or synthetic DNA.
- **III-F-8:** Those that do not present a significant risk to health or the environment, as determined by the NIH Director, with the advice of the RAC, and following appropriate notice and opportunity for public comment.

G. Select Agents

In United States law, **select agents** are biological agents or biological toxins which have been declared by the U.S. Department of Health and Human Services or by the U.S. Department of Agriculture to have the "potential to pose a severe threat to public health and safety". The Centers for Disease Control administers the Select Agent Program (SAP), which regulates the laboratories which may possess, use, or transfer select agents within the United States. The SAP was established to satisfy requirements of the USA PATRIOT Act and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, which were enacted in the wake of the September 11, 2001 attacks and the subsequent 2001 anthrax attacks. Each agency has developed and will maintain a list of Select Agents, including human, animal and plant pathogens, high-risk toxins of biological origin, and prions. The current list of Select Agents can be accessed at the CDC and USDA websites.

In an effort to comply with the regulations, the university has developed very stringent policies to be followed when investigators plan to use select agents. Please go the Biosafety Committee website to read the University's Select Agent Policy and Procedure Manual.

1. Toxin Amounts Permissible Per Principal Investigator

- Although regulated toxins of biological origin are on the select agent list, certain toxins can be ordered, used, or maintained in the laboratory provided the total quantity per PI, for all areas under the PI's control, **does not exceed the limits** posted in the table below for each toxin.
- It is mandatory that PIs contact and receive approval from EHRS prior to ordering toxins even if the amount of toxin is within the permissible quantity. Toxins ordered used, or in the possession of a Drexel's PI cannot exceed the current published maximum allowable exempt quantities (see below) unless both Drexel University and the Principal Investigator are registered with the applicable governmental institution.
- If the total quantity of a toxin under one PI's control exceeds the amount listed in the below table, notify EHRS Biosafety, to register as a potential Select Agent Toxin user.
- EHRS will then inspect your toxin inventory more frequently to check against the maximum allowable exempt quantity.

Toxin Amounts Permissible per Principal Investigator	
HHS Toxins	**Maximum Allowable Exempt Quantity**
Abrin	100 mg 50 mg
Botulinum neurotoxins	0.5 mg 0.25 mg
Clostridium perfringens epsilon toxin	100 mg 50 mg
Conotoxin	100 mg 50 mg
Diacetoxyscirpenol (DAS)	1000 mg 500 mg
Ricin	100 mg 50 mg
Saxitoxin	100 mg 50 mg
Shiga-like ribosome inactivating proteins	100 mg 50 mg
Shigatoxin	100 mg 50 mg
Staphylococcal enterotoxin	5.0 mg 2.5 mg
Tetrodotoxin	100 mg 50 mg
T-2 toxin	1000500 mg

2. Dual-Use Research

On March 29th, the U.S. government issued a government-wide policy to establish procedures for the review of biological research when the research could pose a threat to public health and safety and trigger dual-use concerns. The policy requires that all federal agencies review all current and future federally-funded research projects related to 15 select agents. If those reviews reveal that research has the potential to be **"dual use research of concern" (DURC),** then the government, in collaboration with the research institution or researcher, must create a risk mitigation plan for the project and the release of the research results. This may include enhanced biosafety procedures, requesting voluntary redaction of the research results, and classification of results.

Appropriate ways to implement this policy is still under consideration.

The Dual Use Research: A Dialogue video provides additional information.

H. Biosafety Levels

Biological safety or biosafety is the application of knowledge, techniques and equipment to prevent personal, laboratory and environmental exposure to potentially infectious agents or biohazards. Biosafety

defines the containment conditions under which infectious agents can be safely manipulated. The objective of containment is to confine biohazards and to reduce the potential exposure of the laboratory worker, persons outside of the laboratory, and the environment to potentially infectious agents. It can be accomplished through the following means:

- **Primary Containment** - Protection of personnel and the immediate laboratory environment through good microbiological technique (laboratory practice) and the use of appropriate safety equipment such as a biosafety cabinet.
- **Secondary Containment** - Protection of the environment external to the laboratory from exposure to infectious materials through a combination of facility design and operational practices.

Combinations of laboratory practices, containment equipment, and special laboratory design can be made to achieve different levels of physical containment. Currently four Biosafety Levels (1-4) define the level of containment necessary to protect personnel and the environment.

1. Biosafety Level 1

A Biosafety Level 1 (BL-1) is the least restrictive, while Biosafety Level 4 (BL-4) requires a special containment laboratory or facility, which is not available at Drexel University. Since most of the research at Drexel is conducted at Biosafety Levels 1 and 2 and some experiments at BL-3, this manual will mainly focus on these three Biosafety Levels. For more information on Biosafety Level 4 refer to *Biosafety in Microbiological and Biomedical Laboratories, US Department of Health and Human Services, Public Health Service, Center for Disease Control and National Institutes of Health, Vth Edition, 2007* or EHRS at ehrs@drexel.edu.

2. Biosafety Level 2

Similar to Level I and is suitable for work involving agents of moderate potential hazard to personnel and the environment. It differs from level I in that:

- laboratory personnel have specific training in handling pathogenic agents and are directed by competent scientists,
- Access to the laboratory is limited when work is being conducted,
- Extreme precautions are taken with contaminated sharp items,
- Certain procedures in which infectious aerosols or splashes may be created are conducted in biological safety cabinets or other physical containment equipment.

3. Biosafety Level 3

Applicable to clinical, diagnostic, teaching, research or production facilities in which work is done with indigenous or exotic agents which may cause serious or potentially lethal disease as a result of exposure by the inhalation route. Laboratory personnel have specific training in handling pathogenic and potentially lethal agents and are supervised by competent scientists who are experienced in working with these agents. Procedures involving the manipulation of infectious materials must be conducted within biological safety cabinets or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment. The laboratory has special engineering and design features.

It is recognized, however, that many existing facilities may not have all the facility safeguards recommended for BL3 (e.g. access zone, sealed penetrations and directional airflow, etc.). In these

circumstances, acceptable safety may be achieved for routine or repetitive operations (e.g. diagnostic procedures involving the propagation of an agent for identification, typing, and susceptibility testing) in BL2 facilities. However, the recommended Standard Microbiological Practices, Special Practices, and Safety Equipment for BL3 must be rigorously followed. The decision to implement this modification of BL3 recommendations should be made only by the laboratory director in consultation with EHRS.

4. Biosafety Level Requirements

A summary of the different biosafety level requirements (BL-1, 2 and 3) is listed in the following tables:

Table 1: Hazard Levels

	Biosafety Levels (BSL)		
	BSL-1	**BSL-2** (Some Agents and Materials Require Enhanced Precautions*)	**BSL-3**
Degree of Hazard	Low Risk: Well characterized agents not known to cause disease in healthy adult humans	Moderate Risk: Agents that cause human disease of moderate hazard	High Risk: Agents that a cause disease of moderate to high hazard that have serious or potentially lethal consequences
Agent Examples	Escherichia coli (laboratory strain)	Listeria monocytogenes	Mycobacterium tuberculosis

Table 2: Standard Microbiological Practices

	Biosafety Levels (BSL)		
	BSL-1	**BSL-2** (Some Agents and Materials Require Enhanced Precautions*)	**BSL-3**
Access to the laboratory	Access does not have to be restricted – however, doors cannot be propped open (in violation of fire code).	Doors to the laboratory are closed when BSL-2 work is being conducted to prevent public access.	Doors to the laboratory are closed and locked to prevent untrained personnel access.
Biohazard signage	No biohazard sign is required.	Biohazard sign must be posted.	Biohazard sign must be posted.
Biohazard solid waste decontamination	Biomedical waste vendor.	Biomedical waste vendor or steam sterilize with EHRS approval.	Steam-sterilize in laboratory – EHRS may grant exceptions in extenuating circumstances.
Biohazardous liquid culture decontamination	10% bleach/water made fresh daily with bleach having an EPA registration number (e.g., Chlorox) for 30 minutes.	10% bleach/water made fresh daily with bleach having an EPA registration number (e.g., Chlorox) for 30 minutes or steam	Steam-sterilize in laboratory – EHRS may grant exceptions in extenuating circumstances.

		sterilize with EHRS approval.	
Eating, drinking, application of cosmetics or contact lenses	Not permitted any time	Not permitted any time	Not permitted at any time.
Contaminated sharps (e.g., needles, blades, glass)	Safe handling practices must be developed and implemented. Substitute plastic ware for glassware whenever possible.	Safe handling practices must be developed and implemented. Substitute plastic ware for glassware whenever possible.	Safe handling practices must be developed and implemented. Substitute plastic ware for glassware whenever possible.
Decontamination of work surfaces	Daily, after finishing work and following spills.	Daily, after finishing work and following spills.	Daily, after finishing work and following spills.
Pipetting	Mechanical device – no mouth pipetting.	Mechanical device – no mouth pipetting.	Mechanical device – no mouth pipetting.
Storage of biohazardous waste material	Double red bags held in rigid, leak-proof containers with biohazard labels on the top and side. Biohazardous waste must be under direct control of the responsible laboratory until it is placed in an EHRS approved storage area.	Double red bags held in rigid, leak-proof containers with biohazard labels on the top and side. Biohazardous waste must be under direct control of the responsible laboratory until it is placed in an EHRS approved storage area.	Double red bags held in rigid, leak-proof containers with biohazard labels on the top and side. Biohazardous waste must be under direct control of the responsible laboratory until it is placed in an EHRS approved storage area.
Hand-washing	Required after working with potentially hazardous materials and before leaving the laboratory.	Required after working with potentially hazardous materials and before leaving the laboratory.	Required after working with potentially hazardous materials and before leaving the laboratory.
Training	The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures.	The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures.	The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures.
Medical surveillance	Recommended where personal health status	Required. Laboratory personnel must be	Required. Laboratory personnel must be

	may result in increased susceptibility to infection or inability to receive vaccinations or prophylactic interventions.	provided with medical surveillance and offered appropriate immunizations.	provided with medical surveillance and offered appropriate immunizations.
Equipment decontamination	Equipment must be cleaned of residues and green tagged by EHRS before repair, maintenance, or removal from laboratory.	Equipment must be decontaminated and green tagged by EHRS before repair, maintenance, or removal from laboratory.	Equipment must be decontaminated and green tagged by EHRS before repair, maintenance, or removal from laboratory.
Animals and plants not associated with the work	Allowed if approved by laboratory director and university policy.	Not allowed in the laboratory.	
Institutional Biosafety Committee approval required for use of glassware	Not applicable.	Recommended/required for some agents which have BSL-2+ containment.	BSL3 practices required

Table 3: Safety Equipment

	Biosafety Levels (BSL)		
	BSL-1	**BSL-2** (Some Agents and Materials Require Enhanced Precautions*)	**BSL-3**
Class II Biological safety cabinet (with annual certification)	Not required.	Required for all aerosol generating processes**	Required for all work.
Sealed rotors or safety cups for centrifuging	Not required.	Required for high concentrations or large volumes of infectious agents. Exception: Centrifuges without secondary containment can be operated inside a certified biosafety cabinet.	Required for all work.
Laboratory coats	Required.	Required.	Required (solid front disposable gown).
Gloves (alternatives to latex gloves should be available)	Recommended.***	Required.	Required.
Eye protection (safety glasses, goggles)	Required. This includes work in the biosafety cabinet.	Required. This includes work in the biosafety cabinet.	Required. This includes work in the biosafety cabinet.
Sleeve protectors	Not required.	Recommended.	
HEPA-filtered vacuum lines	Required.		

Table 4: Laboratory Facilities

	Biosafety Levels (BSL)		
	BSL-1	**BSL-2** (Some Agents and Materials Require Enhanced Precautions*)	**BSL-3**
Ventilation	Negative pressure. No recirculation or exhaust air to other areas of the building is permitted.	Negative pressure. No recirculation or exhaust air to other areas of the building is permitted.	Negative pressure. No recirculation or exhaust air to other areas of the building is permitted.
Hand washing facilities	Required.	Required	Required (foot/elbow/electronic operation)
Autoclave	Not required.		Required in laboratory.
Eyewash station	Recommended. However, use of hazardous chemicals may change this to a requirement.	Required.	Required in laboratory.
Doors	Required. Doors should be self-closing and have locks.	Required. Doors should be self-closing and have locks.	Required. A series of 2 self-closing doors is the basic requirement for entry. The space between the 2 doors is called the anteroom. Palm scanners are used to restrict access.
Chairs	Chairs used in laboratory work must be constructed with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.	Chairs used in laboratory work must be constructed with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.	Chairs used in laboratory work must be constructed with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
Cleaning and decontamination	Laboratory design should allow the facility to be easily cleaned and decontaminated. Carpets and rugs are not appropriate.	Laboratory design should allow the facility to be easily cleaned and decontaminated. Carpets and rugs are not appropriate.	Laboratory design should allow the facility to be easily cleaned and decontaminated. Carpets and rugs are not appropriate. Seams, floors, walls, and ceiling surfaces should be sealed. Spaces around doors and ventilation openings

			should be capable of being sealed to allow for space fumigation.

*** Enhanced precautions (BSL-2+):** In some instances, the Institutional Biosafety Committee (IBC) and EHRS will work with PI's to develop lab specific procedures (SOPs) that exceed normally accepted BSL2 procedures but fall short of full BSL3 operations and containment. These SOPs are developed in an effort to protect human health and the environment when RG2 or RG3 pathogens are used in ways that are expected to increase the risk of an agent or animal or increase the risk of exposure to agents but do not really warrant BSL3 containment.

**** Aerosol generating processes include:**
- Centrifuging
- Grinding
- Blending
- Vigorous shaking or mixing
- Sonic disruption
- Opening containers with high internal pressures
- Inoculating animals intra-nasaly
- Harvesting tissues from animals or embryonate eggs

***** BSL-1 gloves:** EHRS requires that researchers don gloves in BSL research labs. This is a Drexel requirement and is above and beyond what is recommended in the BMBL or NIH guidelines.

I. Biological Safety Cabinets

A Biological Safety Cabinets (BSC) is an enclosed, ventilated laboratory workspace for safely working with materials contaminated with (or potentially contaminated with) pathogens requiring a defined biosafety level. Several different types of BSC exist, differentiated by the degree of bio-containment required.

The purpose of a BSC is to serve as the primary means to protect the laboratory worker and the surrounding environment from pathogens. All exhaust air is HEPA-filtered as it exits the biosafety cabinet, removing harmful bacteria and viruses. Most classes of BSCs have a secondary purpose to maintain the sterility of materials inside. This is in contrast to a **laminar flow** clean bench, which blows unfiltered exhaust air towards the user and is not safe for work with pathogenic agents. Likewise, a **chemical fume hood** fails to provide the environmental protection that HEPA filtration in a BSC would provide. BSCs are not safe for use for chemical vapors.

Biological Safety Cabinets are the principal equipment used to provide physical containment. They are used as primary barriers to prevent the escape of aerosols into the laboratory environment. This is an important function, because most laboratory techniques are known to produce inadvertent aerosols that can be readily inhaled by the laboratory worker. Certain cabinets can also protect the experiment from airborne contamination.

The selection of a Biological Safety Cabinet is based on the potential hazard of the agent used in the experiment, the potential of the laboratory technique to produce aerosols, and the need to protect the

experiment from airborne contamination. The similarities and differences in protection offered by the various classes of BSCs and considerations pertinent to BSC selection are provided below.

1. Class I Biological Safety Cabinet (BSC)

Class I BSC is a negative-pressure, ventilated cabinet usually operated with an open front and a minimum face velocity at the work opening of at least 75 linear feet per minute (lfpm). All of the air from the cabinet is exhausted through a HEPA filter either into the laboratory or to the outside. A wide range of activities is accommodated using equipment as varied as pipetting aids, burettes, pH meters, sonicators, shielded centrifuges, blenders, and lyophilizers. Chemical carcinogens, low levels of radioactive materials and volatile solvents can be used in Class I cabinets equipped with ducted exhaust (connected via thimble) and a minimum face velocity of 100 ft/min. When these materials are used in the Class I cabinet, a careful evaluation must be made to determine that concentrations do not reach dangerous levels or cause problems of decontamination of the cabinet. These cabinets are not appropriate for handling research materials that are vulnerable to airborne contamination, since the inward flow of unfiltered air from the laboratory can carry microbial contaminants into the cabinet.

The cabinet is a partial containment unit. Its primary barrier function can be compromised by the pumping action of sudden withdrawal of the hands, the opening and closing of the room door, or rapid movements past the front of the cabinet. Aerosols created in large quantities, and forcefully, may overcome even higher face velocities. Also, the cabinet does not protect the experimenter's hands and arms from contact with hazardous materials. Such protection is dependent on technique, the use of gloves and other personal protective equipment.

2. Class II Biological Safety Cabinet

The Class II BSC is designed with inward air flow at a velocity to protect personnel (75-100 lfpm), HEPA-filtered downward vertical laminar airflow for product protection, and HEPA-filtered exhaust air for environmental protection. Design, construction, and performance standards for Class II BSCs, as well as a list of products that meet these standards, have been developed by and are available from the National Sanitation Foundation International, Ann Arbor, Michigan. Utilization of this standard and list should be the first step in selection and procurement of a Class II BSC.

Class II cabinets have a front opening for access to the workspace and for introduction and removal of materials. Airborne contaminants in the cabinet are prevented from escaping across this opening by a curtain of air formed by (i) unfiltered air flowing from the room into the cabinet and (ii) HEPA filtered air supplied from an overhead grille in the cabinet. This curtain of air also prevents airborne contaminants in the room air from entering the workspace of the cabinet across the front opening. The curtain of air is drawn through a grille at the forward edge of the work surface into plenum below. Air from this plenum is HEPA filtered and re-circulated through the overhead grille down into the cabinet. A portion of this filtered air is used to maintain the air curtain and the remainder passes down onto the work surface and is drawn out through grilles at the back edge of the work surface. The HEPA filtered air from the overhead grille flows in a uniform downward movement to minimize air turbulence. It is this air that provides and maintains a clean-air work environment.

Class II BSCs are classified into two types (A and B) based on construction, air flow velocities and patterns, and exhaust systems. Basically, Type A cabinets are suitable for microbiological research in the absence of volatile or toxic chemicals and radionuclides, since air is recirculated within the cabinet. Type A cabinets are further sub-typed into types A1 and A2. Type A2 cabinets were previously called Type B3

cabinets. Type A cabinets may be exhausted into the laboratory or to the outdoors via a "thimble" or canopy connection to the building exhaust system.

Type B cabinets are further sub-typed into types B1 and B2. Type B cabinets are hard-ducted to the building exhaust system and contain negative pressure plena. These features, plus a face velocity of 100 lfpm, allow work to be done with toxic chemicals or radionuclides.

Class II A1 Biological safety cabinet characteristics

- 75 lfpm inward airflow
- HEPA filtered downward airflow from a common plenum
- May exhaust HEPA-filtered air back into the laboratory or to the outside atmosphere
- May have positive pressure contaminated ducts and plenums
- 70% Class II A1 Biological safety cabinet characteristics of air is recirculated within the hood.

Class II A2 Biological safety cabinet characteristics

- 100 lfpm inward and 70 lfpm downward airflow
- HEPA filtered downward airflow
- May exhaust HEPA-filtered air back into the laboratory or to the outside atmosphere
- Biologically contaminated ducts and plenums are under negative pressure
- 70% of air is recirculated within the hood

Class II B1 Biological safety cabinet

- 100 lfpm inward and 50 lfpm downward airflow
- HEPA filtered downward airflow
- Exhausts all air to the outside atmosphere after HEPA filtration
- May have biologically contaminated ducts and plenums under negative pressure
- 30% of air is recirculated within the hood

Class II B2 Biological safety cabinet

- 100 lfpm inward and 80 lfpm downward airflow
- HEPA filtered downward airflow
- Exhausts all air to the outside atmosphere after HEPA filtration
- Does not recirculate air within the cabinet or work area
- All contaminated ducts and plenums are under negative pressure

3. Class III Biological Safety Cabinet

Class III BSC is a totally enclosed, ventilated cabinet of gas-tight construction and offers the highest degree of personnel and environmental protection from infectious aerosols, as well as protection of research materials from microbiological contaminants. Class III cabinets are most suitable for work with hazardous agents that require Biosafety Level 3 or 4 containment.

All operations in the work area of the cabinet are performed through attached arm length rubber gloves or half-suits. The Class III cabinet is operated under negative pressure. Supply air is HEPA-filtered and the

cabinet exhaust air is filtered through two HEPA filters in series, or HEPA filtration followed by incineration, before discharge outside of the facility.

Materials are introduced and removed through attached double-door sterilizers and dunk baths with liquid disinfectants. The usual utility services can be provided, but not gas. Liquid wastes go to a holding tank for appropriate decontamination before release into "common" sewage lines. Stainless steel is the usual construction material. Modular designs provide for inclusion of refrigerator, incubator, deep freeze, centrifuge, animal holding, and other special cabinet units.

The Class III cabinet provides the highest level of personnel and environmental protection. Protection is also provided to the product (experiment). Most laboratory activities can be accommodated: the usual cultivation of microorganisms, fertile eggs, tissue cells; microscopy, serology; animal dissections and injections; experimental aerosol exposures; various physical measurements; and many others, on small- to large-scale. Selected gaseous atmospheres can be maintained at desired humidity and temperature conditions.

All equipment required by the laboratory activity, such as incubators, refrigerators, and centrifuges, must be an integral part of the cabinet system. The Class III cabinet must be connected to a double-door autoclaves and/or chemical dunk tank used to sterilize or disinfect all materials exiting the cabinet, and to allow supplies to enter the cabinet. Several Class III cabinets are therefore typically set up as an interconnected system.

4. Procedures for the proper use of BSC

- Obtain approval from the Office of Radiation Safety at 215-762-4050 prior to using radioactive materials within the cabinet.
- Do not use gas burners or alcohol flames in biosafety cabinets.
- Keep rear exhaust and front air intake grilles unobstructed so as not to hamper proper airflow into and within the cabinet.
- Do not modify or tamper the biological safety cabinet alarm, sash, electrical, etc. All modifications must be reviewed and performed by a qualified individual.
- Do not store boxes or other materials on top of the cabinet.
- Turn off the ultraviolet (UV) light while working in the laboratory.
- Allow cabinet to run five minutes each day prior to use.
- Wipe down the work surface of the hood with disinfectant (10% bleach, 70% ethanol or Alcide) before beginning work and after finishing the work.
- Decontaminate any objects that were used inside the cabinet.
- Segregate sterile and contaminated items.
- Use horizontal pipette discard pans that contain an effective disinfectant solution inside the cabinet and not use vertical pipette canisters placed on the floor outside of the cabinet.
- Waste bags shall be placed in the rear of the cabinet and not taped onto the front of the cabinet.
- Place all equipment which may produce air turbulence (e.g., centrifuge) near the rear of the hood and stop all other work while this equipment is running.
- Use vacuum filters and traps on the intake end of all vacuum systems.
- Minimize movement in and around the cabinet.
- Use proper personal hygiene to prevent product and user contamination.

As with any other piece of laboratory equipment, personnel must be trained in the proper use of the biological safety cabinets. Of particular note are activities that may disrupt the inward directional airflow.

Repeated insertion and withdrawal of the workers' arms into and out of the work chamber, opening and closing doors to the laboratory or isolation cubicle, improper placement or operation of materials or equipment within the work chamber, or brisk walking past the BSC while it is in use have been demonstrated to cause the escape of aerosolized particles from within the cabinet. Class I and II cabinets must be located at least four feet away from traffic patterns and doors. Air flow from fans, room air supply louvers and other air moving devices can disrupt the airflow pattern at the face of the cabinet. Strict adherence to recommended practices for the use of BSCs and their proper placement in the laboratory are as important in attaining the maximum containment capability of the equipment as is the mechanical performance of the equipment itself.

EHRS is also responsible for ensuring that testing and certification of BSCs is performed. BSCs must be tested whenever they are installed, moved or whenever maintenance is performed, otherwise, they are tested once a year. The cabinet cannot be serviced or moved without approval from the Principal Investigator or the Biosafety Officer when necessary. Further, for their own protection, mechanics must have a written order to work on any hood.

J. Safe Use of Laboratory Equipment

1. Centrifuges and Centrifugation

All centrifugations shall be done using centrifuge safety buckets or sealed centrifuge tubes in sealed rotors. If a small centrifuge is used and centrifuge safety cups are not available, the centrifuge should be operated in the biological safety cabinet. In an effort to reduce the risk of aerosols containing potentially pathogenic agents, a safety centrifuge cabinet or safety centrifuge enclosed carriers may be used to house or safeguard centrifuging of infectious substances.

Each person operating a centrifuge should be trained on proper operating procedures. Keep a log detailing operation record for centrifuges and rotors to assist in determining service requirements.

The following procedures for centrifugation are recommended:

- Examine tubes and bottles for cracks or stress marks before using them.
- Fill and decant all centrifuge tubes and bottles within the biological safety cabinet. Wipe outside of tubes with disinfectant before placing in safety cups or rotors.
- Never overfill centrifuge tubes as leakage may occur when tubes are filled to capacity. The maximum for centrifuge tubes is 3/4 full.
- Always cap tubes before spinning.
- Place all tubes in safety buckets or sealed rotors. Inspect the "O" ring seal of the safety bucket and the inside of safety buckets or rotors. Correct rough walls caused by erosion or adhering of matter and remove debris from the rubber cushions.
- Wipe exterior of tubes or bottles with disinfectant prior to loading into rotor or safety bucket.
- Never exceed safe rotor speed.
- Stop the centrifuge immediately if an unusual condition (noise or vibration) begins.
- Wait five minutes after the run before opening the centrifuge. This will allow aerosols to settle in the event of a breakdown in containment.
- Do not open the lid while the rotor is moving.
- Wear a face shield and/or safety goggles.
- If you see the centrifuge wobbling or shaking, pull the plug.
- Decontaminate safety carriers or rotors and centrifuge interior after each use.

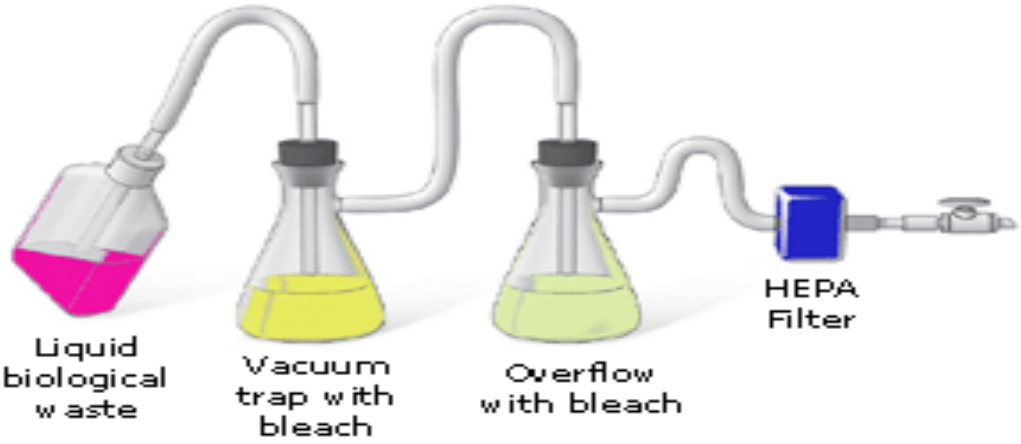
- Open safety buckets or rotors in a biological safety cabinet. If the rotor does not fit in the biological safety cabinet, use the fume hood.
- If construction of the centrifuge permits, the centrifuge chamber is to be connected to a vacuum pump with a HEPA filter installed between the centrifuge and the vacuum pump.
- A germicidal solution added between the tube and trunnion not only disinfects the outer surface of both or these but also provides an excellent cushion against shocks that might otherwise break the tube.
- Video training for microfuge and tabletop centrifuge operation
- Mirofuge Video
- Table Top Centrifuge Video

2. Vacuum lines, Filters and Traps.

Vacuum systems (both centralized and standalone pumps) are commonly used to help researchers filter reagents and dispose of waste among other uses. It is very important to protect your vacuum system from the biohazardous pathogens and toxins routinely used in research. Protecting the central vacuum keeps other labs, building staff, and the environment safe, and protecting portable vacuum pumps reduces the risk of contaminating the lab with dangerous aerosols.

The OSHA bloodborne pathogen standard states "Vacuum lines shall be protected with liquid disinfectant traps and high efficiency particulate air (HEPA) filters or filters of equivalent or superior efficiency which are checked routinely and maintained or replaced as necessary."

The image below is an example of safety equipment and accessories that meet University policy requirements for vacuum line protection. These items can be purchased from many distributors (Fisher Scientific, VWR, etc.).



Vacuum Line Protection: The first sidearm flask functions as the vacuum trap and the second acts as the overflow back-up. These two flasks contain enough household bleach so that the final concentration of waste is 10% bleach when full. An in-line HEPA filter is the last defense and prevents aerosols from entering the line. The flasks should be set in a plastic bucket or tray so that if they break the spill is easily contained. This image is adapted from the Biosafety in Microbiological and Biomedical Laboratories (BMBL).

3. Using UV Lamps in Biological Safety Cabinets

Ultraviolet light is not recommended for use in Class II (laminar flow) biosafety BSC. The NIH, CDC, NSF/ANSI, and ABSA all concur that the use of UV is neither recommended nor necessary in BSCs. A significantly more effective and recommended strategy to reduce or eliminate contamination utilizes well-practiced microbiological procedures, good aseptic techniques, standard operational procedures for working in BSCs, and thorough decontamination procedures with a tested, effective disinfectant before and after BSC use.

- UV irradiation of the work area should only be used as a SECONDARY method of maintaining the disinfected status of a cabinet. It should NEVER be relied on alone to disinfect a contaminated work area. A liquid chemical disinfectant should be the primary method of cleaning and disinfecting the interior of a BSC. All containment devices (such as biological safety cabinets) that have a use limited to Risk Group 1 agents and/or animal pathogens should have all interior surfaces cleaned before and after each use by wiping down all non-porous surfaces with 70% ETOH. Any containment device utilized for any Risk Group 2 or higher agent, any known human pathogen and/or unfixed human blood, tissue or other bodily fluid should be disinfected prior to and after use by wiping all non-porous surfaces with 10% bleach solution followed by sterile water or 70% ETOH.
- UV light is ineffective if a microbial cell is protected by dust, dirt, or organic matter.
- The intensity of the UV lamp is affected by the accumulation of dust and dirt on its surface.
- UV light does not penetrate cracks or seams so will not disinfect the spill area under the work surface
- The UV lamp should NEVER be on while an operator is working in the cabinet, as exposure to UV light can cause painful eye and skin burns.
- The fan should be off, and the sash should be closed, if possible, when the UV light is on.
- Do not touch a UV bulb with your bare hands. The natural oils on your hand may leave a fingerprint and create dead space on the bulb's surface.
- UV bulbs must be cleaned frequently by turning off the UV light and wiping off the surface of the room temperature bulb with 70% alcohol.
- Warning signage (see below) is REQUIRED on the front of the BSC which indicates the presence of UV light hazards along with general usage and personal protection requirements. Contact EHRS at safeheal@drexel.edu to obtain the signage and additional information on the usage and maintenance of UV lamps.

WARNING

THIS DEVICE PRODUCES POTENTIALLY HARMFUL UV LIGHT
PROTECT EYES AND SKIN FROM EXPOSURE TO UV LIGHT

4. Homogenizers, Blenders, Mixers, Sonicators and Cell Disruption Equipment

These items are commonly used in laboratories, and both are considered producers of aerosols. Safety sealed homogenizers and blenders are commercially available and should be used when working with those agents known or suspected of being transmitted through aerosols. The purpose of these items is to contain any aerosols created during work procedures. These safety devices may be used on the open bench top; however, they must be opened in a BSC. All non-sealed devices must be used exclusively in a BSC.

The laboratory practices generally required when using equipment that may generate aerosols with biohazardous materials are listed below.

- Operate blending, cell disruption, and grinding equipment in a BSC.
- Use safety blenders designed to prevent leakage from the rotor bearing at the bottom of the bowl. In the absence of a leak-proof rotor, inspect the rotor for leakage prior to operation. A preliminary test run with sterile water, saline, or methylene blue solution is recommended prior to use.
- If the blender is used with infectious material place a towel moistened with an appropriate disinfectant over the top of the blender. Sterilize the device and residual contents promptly after use.
- Glass blender bowls are undesirable for use with infectious material because of the potential for glass bowls to break.
- Blender bowls sometimes require supplemental cooling to prevent destruction of the bearings and to minimize thermal effects on the product.
- Before opening the safety blender bowl, permit the blender to rest for at least one minute to allow settling of the aerosol cloud.
- Grinding of infected tissues or materials with any open device is best done within a BSC.

5. Microtome/Cryostat

Due to the very sharp blade and the nature of the materials used with the microtome/cryostat, training is essential in the use of the equipment and in the hazards of the materials used with the equipment. Users should be informed of the need to prevent cuts and scrapes as well as protect the eyes, nose, mouth and skin from exposure to the materials being used.

New personnel must be trained in the proper use and maintenance of the equipment and demonstrate proficiency prior to use.

If using human tissue, microtome/cryostat users are required to take Bloodborne Pathogens training. Fixatives take time to penetrate tissue; the fixatives may not inactivate pathogens deep in the tissue. Freezing and drying do not inactivate most pathogens, so, as with fixative use, the pathogens that may be present in the tissue should be considered capable of causing infection.

Microtome/cryostat users shall obtain general laboratory training for chemical use due to the fixatives and dyes used in histology.

When purchasing new units, the available safety features should be taken into consideration prior to deciding on a manufacturer or model. Some available safety features are:

- Auto-decontamination cycle.
- Easy blade release for installing and changing blades.
- Retractable knife/blade to permit safe entry into chamber for cleaning, retrieving specimens, etc.

- Disposable blades.

Never retrieve samples, change blades, or clean equipment by hand with the blade in place; always use appropriate engineering controls (i.e. forceps, tweezers, dissecting probes, and small brushes).

Following items must be remembered for using and maintaining microtomes/cryostats.

- Always keep hands away from blades.
- Use extreme caution when aligning blocks, the blocks may be close to the blades. If available, make sure block holder is in locked position when loading/aligning blocks.
- Use knife-edge protectors/guards. Do not leave knife-edges that may extend beyond microtome knife holder unprotected.
- Keep blocks wet when in the microtome to minimize airborne shavings during slicing.
- Use brushes to clean/brush equipment.
- Use engineering controls such as forceps when removing or changing the blade.
- Dislodge stuck blocks using mechanical means such as forceps and/or dissecting probes.
- Wear appropriate PPE such as a lab coat or gown, mask, safety glasses or goggles, gloves that provide dexterity and cut protection, and examination gloves to protect against biohazards.
- When changing blades, wear cut resistant gloves to provide additional protection from cuts and scrapes.
- Avoid freezing propellants that are under pressure as they may cause splattering or droplets of infectious materials.
- Decontaminate equipment on a regular schedule using an appropriate disinfectant.
- Consider trimmings and sections of tissue as contaminated and discard in the appropriate waste stream.
- Do not move or transport microtome with knife in position.
- Do not leave knives out of containers when not in use.
- Do not leave motorized microtomes running unattended.

6. Water baths, Cold Storage and Shakers

Water baths and Warburg baths used to inactivate, incubate, or test infectious substances should contain a disinfectant. For cold water baths, 70% propylene glycol is recommended. Sodium azide should not be used as a bacteriostatic. It creates a serious explosion hazard.

Deep freeze, liquid nitrogen, and dry ice chests as well as refrigerators should be checked, cleaned out periodically to remove any broken ampoules, tubes, etc. containing infectious material, and decontaminated. Use rubber gloves and respiratory protection during this cleaning.

All infectious or toxic material stored in refrigerators or deep freezers should be properly labeled. Security measures should be commensurate with the hazards.

The degree of hazard represented by contaminated liquid nitrogen reservoirs will be largely dependent upon the infectious potential of the stored microorganisms, their stability in liquid nitrogen, and their ability to survive in the airborne state. Investigations suggest that storing tissue culture cell lines in containers other than sealed glass ampoules might result in potential inter-contamination among cell lines stored in a common liquid nitrogen repository.

Care must be exercised in the use of membrane filters to obtain sterile filtrates of infectious materials. Because of the fragility of the membrane and other factors, such filtrates cannot be handled as noninfectious until culture or other tests have proved their sterility.

Shaking machines should be examined carefully for potential breakage of flasks or other containers being shaken. Screw-capped durable plastic or heavy walled glass flasks should be used. These should be securely fastened to the shaker platform. An additional precaution would be to enclose the flask in a plastic bag with or without an absorbent material.

7. Sharps Containers

The CDC estimates that more than 800,000 accidental needle sticks occur annually among healthcare employees.

To protect workers from pathogens and instruments that come in contact with them, they must be properly disposed in approved sharps containers. Sharps containers are commonly constructed with rigid plastic material and colored red with a biohazard label. The OSHA defines a contaminated sharp as "any contaminated object that can penetrate the skin including, but not limited to, needles, scalpels, broken glass, broken capillary tubes, and exposed ends of dental wires." Sharp containers must be rigid, tightly lidded, leak proof, and puncture resistant. They must be labeled with the word "Biohazard" and the biohazard symbol. Anything that is sharp or glass must be placed inside the sharps container. Never allow sharps to stick out of the opening or above the "fill line".

8. Flow Cytometers

The IBC must review all protocols involving cell sorting. Additional SOPs may be developed to help protect human health and the environment from aerosols that can be produced during the cell sorting process. Cells may need to be sorted under a higher level of containment than how they are handled for other manipulations. When sorting potentially infectious unfixed cells, it is important to keep in mind that potentially infectious aerosols are generated. When the cell sorter fails to operate properly (e.g., a clogged sort nozzle) there can be an increased production of aerosols. High speed sorters also produce an increased amount of aerosols. Because of this risk it is recommended that the aerosol containment of the cell be verified. The following precautions should also be taken:

- Additional biosafety features can be installed to Universal precautions should be followed.
- Appropriate PPE should be worn (i.e., lab coat, gloves, N-95 respirator, splash goggles, face shield if desired);
- If possible, the cell sorter should be located in a separate room.
- The sorter should be operated according to the manufacturer's recommendations; and decontaminate the sorter after each run using an appropriate disinfectant. The disinfectant should be run through the machine for at least 10 minutes.
- Sorting experiments should not be initiated until they are reviewed by the IBC and EHRS.

K. Bloodborne Pathogen Safety

Bloodborne pathogens are pathogenic microorganisms that are present in human blood and can cause disease in humans. The pathogens include but are not limited to: Hepatitis Viruses and Human Immunodeficiency Virus (HIV).

Universal precautions must be observed to prevent contact with blood or other potentially infectious materials. Under circumstances in which differentiation between body fluid types is difficult or impossible, all body fluids shall be considered potentially infectious materials. Treat all bodily fluids / materials as infectious, including any and all instrumentation and materials which may have come in contact with body fluids such as paper, gauze, bandages, sponges, gloves, etc. **Universal Precautions shall be observed at all times.**

A copy of the University's Bloodborne Pathogen Exposure Control Plan can be found on the Biological Safety webpage or by contacting EHRS at ehrs@drexel.edu.

1. Exposure Control Plan

An Exposure Control Plan provides documentation of the procedures which have been devised to reduce employee exposure to bloodborne pathogens in accordance with Occupational Safety and Health Administration (OSHA) Standard **29 CFR Part 1910.1030** - Occupational Exposure to Bloodborne Pathogens.

The Exposure Control Plan contains the following elements:

- An exposure determination
- The schedule and method of implementation for:
  - Methods of Compliance,
  - HIV and HBV Research Laboratories and Production Facilities,
  - Hepatitis B Vaccination and Post-Exposure Evaluation and Follow-up,
  - Communication of Hazards to Employees, and
  - Record keeping, of this standard, and
- The procedure for the evaluation of circumstances surrounding exposure incidents.

The Exposure Control Plan must be accessible to laboratory personnel at all times. An electronic copy of the completed plan must be sent to EHRS at ehrs@drexel.edu Laboratories to which the bloodborne pathogen exposure control plan is not applicable must print the cover page of the plan and write "Not Applicable". This must be posted on the laboratory entrance door at all times.

The Exposure Control Plan must be reviewed and updated at least annually and whenever necessary to reflect new or modified tasks and procedures which affect occupational exposure and to reflect new or revised employee positions with occupational exposure.

The Exposure Control Plan shall document annual consideration and implementation of appropriate commercially available and effective safer medical devices designed to eliminate or minimize occupational exposures.

Laboratories required to complete an Exposure Control Plan must solicit input from laboratory personnel responsible laboratory procedures that may potentially expose the personnel to blood or body fluids. The identification, evaluation, and selection of effective engineering and work practice controls shall be documented in the Exposure Control Plan. The Exposure Control Plan shall be made available to OSHA upon request for examination and copying.

2. Hand Hygiene

- Hand washing facilities shall be readily accessible to employees.
- When provision of hand washing facilities is not feasible, an appropriate antiseptic hand cleanser in conjunction with clean cloth/paper towels or antiseptic towelettes shall be provided. When antiseptic hand cleansers or towelettes are used, hands shall be washed with soap and running water as soon as possible.
- Wash hands immediately or as soon as possible after removal of gloves or other personal protective equipment.
- Wash hands and any other skin with soap and water, or flush mucous membranes with water immediately or as soon as possible following contact of such body areas with blood or other potentially infectious materials.
- Exercise hand hygiene prior to putting on gloves and immediately after gloves are removed.
- It may be necessary to exercise hand hygiene between tasks and procedures.

3. Housekeeping

- All work areas and surfaces must be maintained in a clean and sanitary condition.
- Contaminated work surfaces shall be decontaminated with an appropriate disinfectant after completion of procedures; immediately or as soon as possible when surfaces are overtly contaminated or after any spill of blood or other potentially infectious materials; and at the end of the work shift if the surface may have become contaminated since the last cleaning.
- Protective coverings, such as plastic wrap, aluminum foil, or imperviously-backed absorbent paper used to cover equipment and environmental surfaces, shall be removed and replaced as soon as possible when they become overtly contaminated or at the end of the work shift if they may have become contaminated during the shift.
- All bins, pails, cans and similar receptacles intended for reuse, and which have reasonable likelihood for contamination shall be inspected and decontaminated on a regularly scheduled basis and cleaned and decontaminated immediately or as soon as possible upon visible contamination.
- Broken glassware which may be contaminated shall not be picked up directly with the hands. It shall be cleaned up using mechanical means, such as a brush and dustpan, tongs, or forceps. Broken glassware must be disposed in biohazard labeled and puncture-resistant sharps container.
- Reusable sharps that are contaminated with blood or other potentially infectious materials shall not be stored or processed in a manner that requires employees to reach by hand into the containers where these sharps have been placed.
- Each employee is responsible for cleaning and decontaminating their individual work areas, surfaces and equipment, in addition to the proper disposal of their PPE, immediately or as soon as surfaces/areas or protective coverings become overtly contaminated, or after the occurrence of a spill of blood or OPIM and following the end of a work shift.
- In the event of a large spill or accident involving blood or OPIM, Environmental Services or contracted housekeeping vendor should be contacted immediately to handle. Personnel Protection Equipment (PPE) is worn to clean all spills.

4. Hepatitis B Vaccination

The Hepatitis B vaccination shall be made available to all employees who have a potential for occupational exposure (as defined by this document). It shall be made available after the employee has received training in occupational exposure and within ten (10) working days of initial assignment unless the employee has previously received the complete HBV vaccination series, antibody testing has revealed that the employee is immune, or the vaccine is contraindicated for medical reasons. Any such employees will be noted accordingly.

- EHRS will schedule an appointment at Occupational Health to receive these vaccinations. If you would like to schedule an appointment, please contact EHS at ehrs@drexel.edu.
- Drexel University shall not make participation in a prescreening program a prerequisite for receiving Hepatitis B vaccination.
- If the employee initially declines the Hepatitis B vaccination but at a later date decides to accept the vaccination, the vaccination shall then be made available. An appointment with Occupational Health must be scheduled through EHRS.
- All employees who decline the Hepatitis B vaccination offered shall sign the OSHA required declination form indicating their refusal. This form can be found in Appendix B of this exposure control plan.
- If a routine titer (booster) dose of Hepatitis B vaccine is recommended by the US Public Health Service at a future date, such titer doses shall be made available at no cost to the employee.

The Hepatitis B vaccination is a series of three (3) shots given over a six (6) month period. After the first shot is administered, the second will be given in one (1) month and the third shot six (6) months from the first shot. After the series is completed, titers must be drawn four (4) to six (6) weeks later or current CDC guidelines to make sure immunity has been achieved. Occupational Health shall provide all of the due dates for the following shots/titer, but it is the employee's responsibility to return to the provider for these services

5. Post-Exposure Evaluation and Follow-up

In the event of an exposure, immediately implement the following procedures:

- **Exposure to the Eyes** - Immediately flush for a minimum of 15 to 20 minutes using the eyewash station.
- **Exposure to Face or Body** - Immediately flush for a minimum of 15 to 20 minutes using the safety shower. Remove contaminated clothing while flushing.
- **Hands** - Immediately flush for a minimum 15 to 20 minutes using the sink. Be sure to use plenty of soap and a strong stream of water. cleanse area with soap and water. Be sure to use plenty of soap and a strong stream of water.

After cleansing, the laboratory personnel must notify supervisor and immediately seek medical care. Employees must seek care at Occupational Health between the hours of 8 AM and 5 PM Monday through Friday. If Occupational Health is unavailable or after hours, visit the nearest Emergency Room. Students should seek medical treatment with his or her family physician, student health, or the closest emergency room.

An Employee Injury Report must be completed within 24 hours. EHRS shall conduct an incident assessment after an exposure incident.

Drexel University shall offer post-exposure evaluation and follow-up at no cost to the employee. Follow-up shall include the following:

- A confidential medical evaluation (determination of type of prophylaxis and medical treatment indicated) under the supervision of a licensed physician or by or under the supervision of another licensed healthcare professional.
- Documentation of route of exposure and circumstances related to the incident.
- Identification and documentation of the source individual, unless Drexel University can establish that identification is infeasible or prohibited by state or local law.
- The source individual's blood shall be tested as soon as possible and after consent is obtained in order to determine HBV and HIV infectivity. If consent is not obtained, Drexel University shall establish that legally required consent cannot be obtained. When the source individual's consent is not required by law, the source individual's blood, if available, shall be tested and the results documented.
- When the source individual is already known to be infected with HBV or HIV, testing for the source individual's known HBV or HIV status need not be repeated.
- Results of the source individual's testing shall be made available to the exposed employee, and the employee shall be informed of applicable laws and regulations concerning disclosure of the identity and infectious status of the source individual.
- The exposed employee's blood shall be collected as soon as possible and tested after consent is obtained.
- If the employee consents to baseline blood collection but does not give consent at that time for HIV serologic testing, the sample shall be preserved for at least ninety (90) days. If, within ninety (90) days of the exposure incident, the employee elects to have the baseline sample tested, such testing shall be done as soon as possible.
- Employee shall be offered post-exposure prophylaxis, when medically indicated, as recommended by the U.S. Public Health Service.
- Drexel University shall ensure that all laboratory tests are conducted by an accredited laboratory at no cost to the employee.
- Counseling and evaluation of reported illnesses shall be given to employee.
- Drexel University shall ensure that the healthcare professional evaluating an employee after an exposure incident is provided the following information; a copy of the Bloodborne pathogen standard; a description of the exposed employee's duties as they relate to the exposure incident; documentation of the route(s) of exposure and circumstances under which exposure occurred; results of the source individual's blood testing, if available; and all medical records relevant to the appropriate treatment of the employee including vaccination status which are Drexel University's responsibility to maintain.
- Drexel University shall obtain and provide the employee with a copy of the evaluating healthcare professional's written opinion within fifteen (15) days of the completion of the evaluation.
- All medical records relevant to the appropriate treatment of the employee including vaccination status which are Drexel University's responsibility to maintain.
- The healthcare professional's written opinion for Hepatitis B vaccination shall be limited to whether Hepatitis B vaccination is indicated for an employee, and if the employee has received such vaccination.
- The healthcare professional's written opinion for post-exposure evaluation and follow-up shall be limited to the following information: that the employee has been informed of the results of the evaluation; and that the employee has been told about any medical conditions resulting from exposure to blood or other potentially infectious materials which require further evaluation or treatment. All other findings or diagnoses shall remain confidential and shall not be included in the written report.

6. Training

All laboratory personnel must be trained prior to performing any procedures that may have the potential to expose the individual to bloodborne pathogens. The training focuses on the contents of the Bloodborne pathogen standard 29 CFR 1910.1030 and information specific to their individuals' work areas. Training

must be completed at the time of initial assignment and annual thereafter. This training must be provided during working hours. The online training can be access through the EHRS website under the Safety Training link.

L. Regulated Medical Waste Disposal

1. Regulate Medical Waste

Infectious waste is any waste with the presence or the reasonable anticipated presence of blood or other potentially infectious materials on an item or surface. The following are typical materials considered infectious wastes (this is not an all-inclusive list).

- Human body fluids like semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, any body fluid that is visibly contaminated with blood, and all body fluids in situations where it is difficult to differentiate between body fluids.
- Any unfixed human tissue or organ (other than intact skin).
- HIV-containing cell or tissue cultures, organ cultures, and HIV or HBV containing culture medium or other solutions.
- Microbiological cultures and stocks of infectious agents, including cultures and stocks of infectious agents, wastes from the production of biologicals, and culture dishes, assemblies and devices used to transfer, inoculate and mix cultures.
- Contaminated animal carcasses, body parts, blood, blood products, secretions, excretions and bedding of animals that were known to have been exposed to zoonotic infectious agents or non-zoonotic human pathogens.
- Pharmaceutical drugs and chemicals that are not infectious must not be disposed in the infectious waste streams.
- Regulated medical waste that is mixed with chemicals, or radioactive agents must be handled in a special manner. Please contact the department EHRS at ehrs@drexel.edu.

2. Regulated Medical Waste Types

There are three types of waste generated in laboratories and disposed of through the regulated medical waste program. These include:

- Regulated medical waste
  - Sharp waste
  - Non-Sharp waste
- Pathological waste
- Chemotherapeutic waste

3. Regulated Medical Sharps Waste

- Any item contaminated with potentially hazardous biological materials that, when broken or intact, may pierce or scratch the skin is considered a “sharp” and must only be disposed in an approved sharps container. This includes but is not limited to syringes, needles, blades, glassware, sharp metal objects and hard plastic items like pipettes, pipette tips, petri dishes, etc. All sharp waste must be placed directly into the approved sharps container. Do not over stuff the container. Close the lid once the container is ¾ full.

- Sharps containers must be puncture resistant, tightly lidded, leak proof and labeled. Cardboard sharps containers are not acceptable for use.
- Sharps contaminated with radioactive agents must be placed in a separate approved sharps container labeled as radioactive and infectious. This waste must not be mixed with non-radioactive regulated medical sharps waste. To dispose radioactive waste, please contact the EHRS at 215-895-5919.

4. Non-sharp Regulated Medical Waste

All wastepaper and soft plastic materials contaminated with potentially hazardous biological materials that will not puncture or leak from bags such as paper towels, gloves, bench top mats, and rounded plastic ware including petri dishes must be placed in RED Regulated Medical Waste bags. These bags must be located within each laboratory performing functions that would generate such waste. Do not over stuff bags. The containers used to hold these bags should be labeled with Biohazard label and the word "Biohazard". These containers should be decontaminated periodically by laboratory personal using a diluted (10%) bleach solution.

High-risk material should be autoclaved by the respective laboratory personnel using the Common Use autoclaves. Red bags should be sealed with tape and identified with a note attached indicating, "AUTOCLAVE AND DISCARD". All material should then be placed in the metal autoclaved cans for disposal.

Infectious liquid waste can be disposed in the following manners:

- Dispose in sanitary sewer after chemical decontamination with a fresh solution of 10% bleach. Wait 15 to 30 minutes prior to discharging down the drain.
- Dispose in RED Biohazardous waste bags provided there is adequate amount of absorbing material present and label Regulated Medical Waste.
- Dispose in a RED Biohazardous waste bag in a leak proof container labeled as Regulated Medical Waste.

5. Pathological Waste

Pathological human waste is any tissue, organ, body part, or body fluids that are removed during surgery, autopsy, other medical procedures or laboratory procedures. This waste must be placed in a RED Biohazard waste bag and keep cold until the day of disposal.

Pathological animal waste is any animal carcasses and body parts that have been or have not been exposed to zoonotic infectious agents or non-zoonotic human pathogens during research. This waste must be placed in RED Biohazard waste bags and sent to the animal facility for disposal.

Liquid pathological waste must be placed in a leak proof container to prevent leakage during the disposal process.

6. Chemotherapeutic Waste

Chemotherapeutic waste must be disposed of in YELLOW Chemotherapeutic Waste bags and labeled as Chemotherapeutic Waste. Removal of these containers from the laboratories is performed in the same manner as the non-sharp infectious waste.

Chemotherapeutic and pathological waste containing potentially infectious materials must be disposed of in RED Biohazard / Infectious Waste bags and labeled as pathological waste. Removal of these containers from the laboratories is performed in the same manner as the non-sharp infectious waste. However, these wastes must be incinerated.

Drugs and chemical agents that are used in conjunction with biological materials or animals are not effectively destroyed through the autoclave process and hence must be sent out for destruction via incineration.

If you have materials or wastes that are chemotherapeutic and you need further assistance in disposing such items, please contact EHRS at ehrs@drexel.edu.

7. Infectious contaminated glassware and equipment

The following procedures must be used regarding the transfer of contaminated glassware and plastic ware to the glass-wash service.

- **Things to be returned to glassware washing facility**
  - All Laboratory Glassware
  - All Bottles Except those used to Contain Chemicals
  - Caps, Stoppers, etc.
  - Pipette Cams
  - Culture Tube Racks
  - Petri Dish Cans
- **Things not to be returned to glassware washing facility**
  - Chemicals
  - Radioactive Materials
  - Animals or Animal Parts, including eggs
  - Plastic Disposables

- **Methods to be followed**
  - Dirty Glassware should be placed in plastic trays only after the trays have been lined with an autoclavable bag. Do not put dirty glassware in an unlined tray.
  - Potentially dangerous items such as Pasteur pipettes, hypodermic needles, syringes, etc. are not to be returned for glassware washing.

8. Regulated Medical Waste Removal Process

Non-sharps regulated medical waste and chemotherapeutic waste bags must be placed in a container that is leak-proof on the sides and bottom, impervious to moisture, and sufficient in strength to prevent puncturing, tearing or bursting during storage. Liquid waste must be placed in containers that are break resistant and tightly lidded. Sharps containers must be puncture resistant, tightly lidded, leak proof and labeled. Cardboard sharps containers are not acceptable for use.

Regulated medical waste and Chemotherapeutic waste containers must be labeled in the following manner by laboratory personnel:

- The words “Regulated Medical Waste” or “Chemotherapeutic Waste”
- The universal biohazard symbol and the work “Biohazard”.
- The date the container was full or the date the container was sealed.

- The name, address and telephone number of the generator of the waste.

Laboratory personnel must seal the waste container prior to removal from the laboratory. The contractor will not seal the container. The waste is removed on the following schedule:

Campus	Removal Service	Schedule	On-site Time
University City	Sharps and Red Bag - Contractor	Weekly	7:30 am to 2 pm
Center City	Sharps and Red Bag – Contractor	Weekly	7:30 am to 2 pm
Queen Lane	Sharps and Red Bag – Contractor	Weekly	7:30 am to 2 pm
Camden	Sharps and Red Bag – Contractor	On-Call	NA
Elkins Park	Sharps and Red Bag – Contractor	On-Call	NA
The Eye Institute	Sharps and Red Bag – Contractor	ON-Call	NA
West Reading	Sharps and Red Bag – Contractor	On-Call	NA

Laboratory personnel must be present during the scheduled pick up time. The contactor will not remove the waste if the laboratory personnel is not present. Regulated medical waste cannot be placed in the hallway for pickup. The waste must be secure at all times. Overfilled containers will not be removed from the laboratory.

This service is offered free of charge to research personnel. To service waste containers or to obtain regulated waste containers, please contact the EHRS at ehrs@drexel.edu.

M. Spills with Potentially Hazardous Biological Materials

If an accident occurs involving the possible spread of potentially dangerous biological material, the following guideline outlines the basic procedures for dealing with some of the biological spills that occur in the research laboratory. All lab personnel should refer to the relevant spill response procedures before initiating their experiments. For comprehensive information of on handling spills download Drexel University Hazardous Material Emergency Response Plan posted on the EHRS website.

1. Composition of a Basic Spill Kit

A spill kit is an essential safety item for labs working with microbiological agents classified at Biosafety Level 2 or higher and for groups working with large volumes (>1 liter) of Biosafety Level 1 material. Every laboratory meeting the above conditions should create a spill kit that contains the following items:

- A spray bottle for making 10% bleach solutions
- Forceps, autoclavable broom and dustpan, or other mechanical device for handling sharps
- Paper towels or other suitable absorbent
- Biohazard autoclave bags for the collection of contaminated spill clean-up items
- Utility gloves and medical examination gloves
- Face protection (eye wear and mask, or full-face shield)

This spill kit should contain several items that can be used to decontaminate the area. The spill kits are not meant for very large spills (>1 liter). Laboratory personnel must implement the emergency response plan in the event of a large biological spill.

2. Small Spills

If only a small amount of material (up to a few ml and/or little or no virulence), simply use a towel to absorb the spill, apply disinfectant to the area let stand for several minutes and wipe up. Rather than pour the disinfectant directly to the spill area and risk splashing, it is better to allow the disinfectant to flow onto the spill.

When dealing with spill, following precautions must be taken:

- Use universal precautions when handling potentially biologically hazardous materials (i.e. personal protective equipment).
- Place absorbed material into a biohazard bag.
- Do not let the spill dry because this will allow contaminated dust to form and spread.

3. Large spills

If a spill of larger volume or of highly virulent material occurs, warn others, hold your breath and leave the room. Warn others not to enter the room. Immediately implement the University Hazardous Material Emergency Response Plan. Contact the Drexel Public Safety 24 Hour Call Center at 215-895-2222. Provide the operator with the specific building name, room number, and nature of spill.

4. Biosafety level 1 spill and clean-up

- Notify others in the area, to prevent contamination of additional personnel and environment.
- Remove any contaminated clothing and wash exposed skin with disinfectant.
- Wearing gloves, lab coat, and face protection, cover spill with paper towels, pour concentrated disinfectant around the spill allowing it to mix with spilled material. Allow suitable contact time.
- Pick up any pieces of broken glass with forceps and place in a sharps container.
- Discard all disposable materials used to clean up the spill into a biohazard autoclave bag.
- Wash hands with soap and hand-washing disinfectant.

5. Biosafety level 2 spill and clean-up

- Avoid inhaling airborne material, while quickly leaving the room. Notify others to leave. Close door, and post with a warning sign.
- Remove contaminated clothing, turning exposed areas inward, and place in a biohazard bag.
- Wash all exposed skin with soap and water.

- Inform Supervisor, and, if assistance is needed, consult the EHRS (215) 895-5919.
- Allow aerosols to disperse for at least 30 minutes before reentering the laboratory. Assemble clean-up materials (disinfectant, paper towels, biohazard bags, and forceps).
- Put on protective clothing (lab coat, face protection, utility gloves, and booties if necessary).
- Depending on the nature of the spill, it may be advisable to wear a HEPA filtered respirator instead of a surgical mask.
- Cover the area with disinfectant-soaked towels, and then carefully pour disinfectant around the spill. Avoid enlarging the contaminated area. Use more concentrated disinfectant as it is diluted by the spill. Allow at least a 20-minute contact time.
- Pick up any sharp objects with forceps and discard in a sharps container. Soak up the disinfectant and spill using mechanical means, such as an autoclavable broom and dustpan, since there may be sharps under the paper towels, and place the materials into a sharps container. Smaller pieces of glass may be collected with cotton or paper towels held with forceps. If no sharps were involved in the spill discard the materials into an autoclave bag.
- Wipe surrounding areas (where the spill may have splashed) with disinfectant.
- Soak up the disinfectant and spill and place the materials into a biohazard bag.
- Spray the area with 10% household bleach solution and allow to air-dry (or wipe down with disinfectant-soaked towels after a 10-minute contact time). Place all contaminated paper towels and any contaminated protective clothing into a biohazard bag and autoclave.
- Wash hands and exposed skin areas with disinfectant or antiseptic soap and water.

NOTE: Refer to "Drexel University Hazardous Material Emergency Response Plan" and Drexel's site-specific response plans for spills involving CDC-regulated select agent and BSL3 pathogens for additional information.

6. Blood Spills

Use the following procedures to clean up blood or other liquid human material with low concentration of infectious microorganisms.

- Wear gloves, eye protection, and a lab coat.
- Absorb blood with paper towels and place in a biohazard bag. Collect any sharp objects with forceps or other mechanical device and place in a sharps container.
- Using a detergent solution, clean the spill site of all visible blood.
- Spray the spill site with 10% household bleach and allow to air-dry for 15 minutes.
- After the 15-minute contact time, wipe the area down with disinfectant-soaked paper towels.
- Discard all disposable materials used to decontaminate the spill and any contaminated personal protective equipment into a biohazard bag.
- Wash your hands.

7. Mixed Biohazard-Radioactive Spills and Clean-up

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 radiochemical while you disinfect the biological material. Before any clean up, consider the type of radionuclide, characteristics of the microorganism, and the volume of the spill. Contact the Radiation Safety at (215) 895-5919 for isotope clean-up procedures and notifying spill. If assistance is needed for handling biological hazardous material, please contact EHRS at (215) 895-5919.

- Avoid inhaling airborne material, while quickly leaving the room. Notify others to leave. Close door and post a warning sign.
- Remove contaminated clothing, turning exposed areas inward, and place in a biohazard bag labeled with a radioactive materials label or a radioactive waste container labeled with a biohazard label.
- Wash all exposed skin with disinfectant, following it with a three-minute water rinse.
- Clean-up of biohazardous radioactive material require additional procedures beyond the clean-up procedures for Biosafety level 2 spill and clean-up (See Section L, 2, d above).
- **DO NOT** use bleach solutions on iodinated material since the interaction results in the release of radioactive gas. Instead use disinfectants such as Iodophor or other appropriate phenolic disinfectant.
- Allow aerosols to disperse for at least 30 minutes before reentering the laboratory. Assemble clean-up materials (disinfectant, paper towels, biohazard bags, and forceps).
- Put on protective clothing (lab coat, face protection, utility gloves, and booties if necessary).
- Depending on the nature of the spill, it may be advisable to wear a HEPA filtered respirator instead of a surgical mask.
- Cover the area with disinfectant-soaked towels, and then carefully pour disinfectant around the spill. Avoid enlarging the contaminated area. Use more concentrated disinfectant as it is diluted by the spill. Allow at least a 20-minute contact time.
- Handle any sharp objects with forceps. Wipe surrounding areas, where the spill may have splashed, with disinfectant.
- Soak up the disinfectant and spill, and place the biologically decontaminated waste, along with all contaminated protective clothing, into an approved radiation container and label it according to Radiation Safety Guidelines. Contaminated protective clothing must also be biologically decontaminated prior to disposal as radioactive waste.
- **DO NOT** autoclave the waste unless the Radiation Safety Officer approves this action. If waste cannot be autoclaved, add additional disinfectant to ensure biological decontamination of all the materials. Wash hands and exposed skin areas with disinfectant; monitor personnel and spill area for residual radioactive contamination.
- If skin contamination is found, repeat decontamination procedures under the direction of the Radiation Safety Officer.
- If the spill area has residual activity, determine if it is fixed or removable and handle accordingly.
- To discard items contaminated with radioactive materials: Place the contaminated item(s) on absorbent paper. Spray disinfectant (10% household bleach) on the contaminated areas and allow 20-minute contact time. Wrap the item(s) inside the paper and dispose of as radioactive waste.

8. Spill in a Biological Safety Cabinet

A spill that is confined to the interior of the BSC should present little or no hazard to personnel in the area. However, chemical disinfection procedures should be initiated at once while the cabinet ventilation system continues to operate to prevent escape of contaminants from the cabinet. Spray or wipe walls, work surfaces, and equipment with a disinfectant. A disinfectant with a detergent has the advantage of detergent activity, which will help clean the surfaces by removing both dirt and microorganisms. A suitable disinfectant is a 3% solution of an Iodophor such as Wescodyne or a 1 to 100 dilution of a household bleach (e.g. Clorox) with 0.7% nonionic detergent. The operator should wear gloves during this procedure. Use sufficient disinfectant solution to ensure that the drain pans and catch basins below the work surface contain the disinfectant. Lift the front exhaust grill and tray and wipe all surfaces. Wipe the catch basin and drain the disinfectant into a container. The disinfectant, gloves, wiping cloth and sponges should be discarded into an autoclave pan and autoclaved. This procedure will not disinfect the filters, blower, air ducts or other interior parts of the cabinet. If the entire interior of the cabinet is to be sterilized contact the EHRS at 215-

895-5919 or by email at ehrs@drexel.edu. If the spill is a mixed biohazardous-radioactive material, contact the Radiation Safety Officer whether procedures described above may be used.

N. Transporting and Shipping Biological Materials

The US Department of Transportation (DOT) and the International Civil Aviation Organization (ICAO) have in place numerous regulations for shipping of dangerous goods by surface or air. Nonconformance of these regulations can result in significant fines up to $250,000 and up to a year in prison for individuals. Organization can be fined up to $500,000 per incident.

The DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA) enforces shipments of hazardous materials within the United States under the Code of Federal Regulation Title 49. The ICAO's Technical Rules have been summarized by the International Air Transport Association (IATA) and published as the Dangerous Goods Regulations (DGR).

A shipper is defined as someone that does any of the following:

- Marking and labeling packages.
- Filling packages.
- Accepting packages for shipment.
- Supervising the shipping activities.
- Preparing shipping documentation.
- Loading trucks.

Anyone packaging, handling, shipping or transporting biological materials must receive training in the general requirements of handling biological materials as well as function specific training for the specific task(s) performed. **EHRS provides online training for shipping patient specimens only**. Laboratory personnel shipping Category A and/or B infectious substances must receive additional training. Training is required before performing any tasks associated with shipping biological materials. Most shipping companies provide shipping training for Category A and/or B infectious substances. The DOT provides free training at http://dothazmat.vividlms.com.

1. Biological Shipment Classifications

a. Patient Specimens

Specimens collected directly from humans or animals, including but not limited to, excreta, secreta, blood and its components, tissue and tissue fluid swabs, and body parts being transported for purposes such as research, diagnosis, investigational activities, disease treatment and prevention.

A sample is considered a patient specimen only if there is no reason to believe that the specimen contains pathogens. In determining whether a patient specimen has a minimal likelihood that pathogens are present, an element of professional judgement is required. The judgement should be based on the known medical history, symptoms and individual circumstances of the source, human or animal, and endemic local conditions.

Patient specimens are not regulated as a Dangerous Good as long as there is a minimal likelihood that pathogens are present. A United Nations (UN) number is not required to ship. If a specimen is known or is reasonably expected to contain pathogens, it must be reclassified and assigned a UN number.

b. Infectious Substances

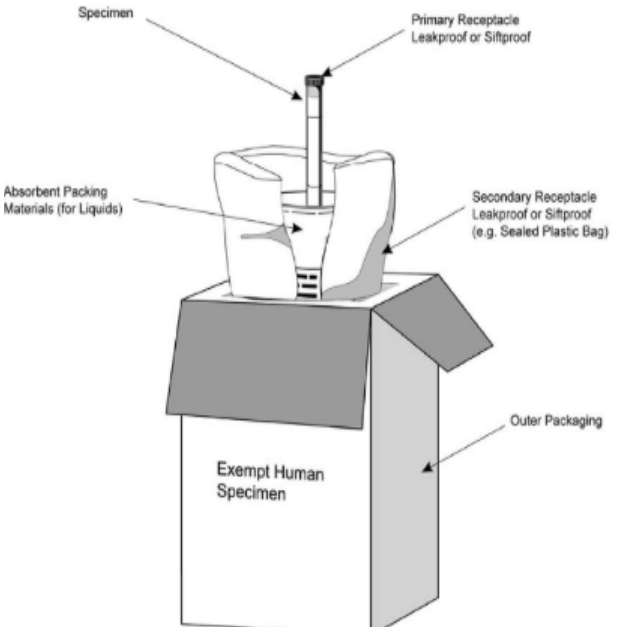
Substances which are known or reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsiae, parasites, fungi) and other agents such as prions, which can cause disease in humans or animals.

- Category A infectious substances or biological products transported in a form that, when exposure to it occurs, is capable of causing permanent disability, life-threatening or fatal disease in otherwise healthy humans or animals. Classification as Category A infectious substance is based on known medical history, symptoms of the source patient or animal, endemic local conditions, or professional judgment concerning the individual circumstances of the source patient or animal. This category is reserved for agents that pose a "high-risk" to those who are exposed. Category A infectious substances are assigned to UN 2814 for humans and UN 2900 for animals.
- Category B infectious substances are biological products that are infectious, but do not meet the criteria for inclusion in Category A. These substances are generally in a form not capable of causing permanent disability or life-threatening or fatal disease in otherwise healthy humans or animals when exposure to it occurs. Category B infectious substances are assigned to UN3373.
- Genetically Modified Organisms or Microorganisms which do not meeting the definition of infectious substances but having genetic material that has been purposely altered through genetic engineering in a way that does not occur naturally must be assigned UN3245. Genetically modified microorganisms and organisms meeting the definition of infectious substances must be re-classified as an infectious substance and assigned to UN 2814, UN 2900, or UN 3373.
- Non-Regulated Materials – Exemptions – the following biological materials are not subject to IATA or DOT shipping regulations, unless they meet the criteria for inclusion in another regulated hazard class:

    - Substances that do not contain infectious substances.
    - Substances which are unlikely to cause disease in humans or animals.
    - Substances containing non-pathogenic micro-organisms.
    - Substances in a form that any present pathogens have been neutralized or inactivated so they no longer pose a health risk.
    - Environmental samples which are not considered to pose a significant risk of infection.
    - Dried blood spots, collected onto absorbent material.
    - Fecal occult blood screening tests.
    - Bloor or blood components and tissue or organs intended for transfusion or transplantation.
    - Biological products including an experimental or investigational product or component of a product, subject to federal approval, permit, review or licensing requirements such as those required by the FDA and USDA.
    - Patient Specimens for which there is minimal likelihood that pathogens are present are not subject to the regulation if the specimen is transported in packaging for Exempt Patient Specimens.

2. Patient Specimens - Packing, Packaging and Marking Shipments

Patient specimens for which there is minimal likelihood that pathogens are present must be packaged in the following manner:



- Leak proof primary receptacle
- Leak proof secondary packaging
- Outer packaging of adequate strength for its capacity, mass, and intended use.
- Outer package with at least one surface having minimum dimensions of 100mm x 100mm.
- For liquids: Absorbent material in sufficient quantity to absorb the entire contents must be placed between the primary receptacle(s) and the secondary packaging.
- When multiple fragile primary receptacles are placed in a single secondary packaging, they must be either individually wrapped or separated to prevent contact.
- The outer container of the patient specimen shipment must include one of the following statements
  - "Exempt Human Specimen" or
  - "Exempt Animal Specimen"

3. Patient Specimen Shipments Requiring Dry Ice

Dry ice must never be shipped in a sealed container. A sealed package can explode from over pressurization created by the evaporation of the dry ice. Dry ice must be in packaging designed and constructed to permit the release of carbon dioxide gas and to prevent a build-up of pressure that could rupture the packaging. Dry ice must always be placed between the secondary and outer container.

The outer shipping container must be labeled with the following if dry ice is used to refrigerate patient specimens:

- Proper shipping name – "Dry Ice" or "Carbon Dioxide, solid"
- Class 9 label orientated in the diamond shape.
- UN 1845
- The approximate net quantity of dry ice used in kilograms.

4. Declaration Form and Air Waybill

The Declaration Form of Dangerous Goods is a legal document and must be completed carefully by the shipper. The Declaration must be completed when shipping Category A Infectious Substances assigned to UN2814 or UN2900 or GMO/GMMO assigned UN2814 or UN2900.

The red hatching on the Declaration is an indication that the item being shipped is a Dangerous Good. Shipping companies require the Declaration document to be computer generated from an approved shipping software program. The shipper must contact the carrier to establish a contract to ship dangerous goods or hazardous materials.

A Declaration is not required for shipments of patient specimens and Category B Infectious Substances. Shipments of patient specimens that require dry ice do not require a Declaration.

5. Transport of biohazardous materials within Drexel University Campuses

Transports of frozen and/or active biomaterials (Risk Group 1 or 2) between Drexel campuses is permitted. Any such material must be transported in a properly labeled container housed within a secondary, labeled and leak proof container. Material must be transported by a person with intimate knowledge of the contents, and they must be trained and found competent to properly address any spills or leaks. Those with Biosafety Level 3 (BSL3) laboratories must contact EHRS at safeheal@drexel.edu for specialized procedures.

The following rules apply when transporting hazardous materials within campuses:

- **Laboratory Personnel to Move Biomaterials in Coolers -** Biomaterials (either active or frozen cultures) may be moved in thermally stable transport containers such as Igloo® or Coleman®-style hard-sided picnic coolers with securing latches. Primary containers must be placed within secondary containers that are leak proof and have tightly fitting lids. A biohazard sticker must be placed on the outside of the secondary container with agent name. Also write the lab address and phone number on the outside of the secondary container.
  - Decontaminate the outside of the primary container before placing in the secondary container.
  - Decontaminate the secondary container before leaving the laboratory.
  - The materials requiring transport at non-ambient temperature must be packed in coolers that include enough heat or cold source packs to keep materials at required temperature for duration of transfer. Wadded newspaper or bags of Styrofoam peanuts are commonly used to take up unused space to prevent contents shifting and to maintain temperature as long as possible. **Do not use loose Styrofoam peanuts**. Outer containers must be sealed and secured shut with heavy-duty duct or shipping tape.
- **Laboratory personnel to move biomaterials without coolers -** Primary containers used to transport biomaterials at ambient temperatures must be placed in leak proof secondary containers with tightly fitting lids. Wadded newspaper or bags of Styrofoam peanuts are commonly used to take up unused space to prevent contents shifting. **Do not use loose Styrofoam peanuts.** Outer container must have biohazardous label affixed and visible.
  - All cultures must be transferred to leak proof, screw-cap unbreakable plastic containers (primary container). **Do not use slip-cap culture tubes or stoppered containers.**
  - All containers with biohazardous materials must display biohazard symbol and have attached to the top outside a leak proof plastic bag that contains the following information:

    a) Name and phone number of the PI and that of an alternate contact,
    b) Originating building and room number,
    c) Destination room number,
    d) Inventory and description of biohazards of contents.

The following additional measures should be taken when transporting biological materials between campuses:

- Biohazardous materials must be transported by two persons with appropriate knowledge of materials involved and emergency procedures in the event of a spill or other accident. Appropriate PPE must be worn (gloves, laboratory coat, safety glasses or goggles, masks or face shields) when actively handling biohazardous materials during packaging and unpacking at new location.
- During transport, street clothes should be worn, but PPE should remain available in case of spills.
- Persons involved in transport must take with them 2 1L spray bottles of fresh 10% bleach solution, sufficient absorbent material to disinfect and remove spills, and sufficient large plastic bags (not red biohazard bags) to contain used absorbent materials.
- After packaging, actual transport of biohazardous materials must be completed within 2 – 3 hours from beginning location to final destination.
- DO NOT move biohazardous materials in incubators.

O. Care and Use of Laboratory Animals

Special attention must be given to the humane treatment of all laboratory animals in accordance with the "Animal Welfare Act of 1996" as amended, the Public Health Service, the PHS "Policy on the Humane Care and Use of Laboratory Animals" and the policies of the University in research. All research experiments involving animals must be conducted in accordance with the Drexel University Animal Care and Use Committee (IACUC) approved protocol. Animal research that biological (human or animal pathogens) and chemical hazards including the use of recombinant DNA material must be approved by UBSC. Use of radioactive material or any type of radiation must be approved by University Radiation Safety Committee. For additional information on the use of animals in research email iacuc@drexel.edu. For additional information on the use of radiation or radioactive materials in research animals, call (215) 215-5919.

1. Animal Care and Use Program

The University's IACUC Guidelines are posted on the IACUC website. The University Laboratory Animal Resources (ULAR) has established procedures to ensure research animals are free of disease prejudicial to the proposed experiments and free from carriers of disease or vectors, such as ectoparasites, which endanger other experimental animals or personnel. Animals are obtained from sources known to be disease free.

Drexel University has developed a written program entitled "Occupational Safety and Health Program for All Personnel Handling or Working Near Laboratory Animals". This program is protocol driven and plays an integral part in protecting the health of individuals working with research animals.

This program outlines medical services that are required for those working with animals. The medical services required are based on the species type, the nature of the research activities as per the IACUC and Biosafety Protocols, and the recommendations of the Occupational Health Physicians.

All individuals included in this program are required to have specific training on the hazards associated with laboratory animals. This training covers the written occupational health program, medical consultations and surveillance, the University Committee's involvement and 16 different topics specific to hazards associated with laboratory animals.

2. Guidelines for Vivarium Maintenance

- Doors to animal rooms should be kept closed at all times, except for necessary entrance and exit.

- Unauthorized persons should not be permitted to enter animal rooms.
- Lab coats, disposable gloves should be worn while handling any animals. After removing gloves, hands must be washed.
- Hazardous that includes syringes, needles, sharps, disposable gloves and aprons must be disposed as hazardous waste using the appropriate hazardous waste containers provided in the animal rooms.
- Floors, walls, and cage racks are washed with an approved disinfectant as directed by the supervisor.
- Floor drains in animal rooms, as well as floor drains throughout the building, should be flooded with water or disinfectant periodically to prevent backup of sewer gases. Some floor drains are intentionally capped in the Animal Facility. e) Shavings and other refuse on floors should not be washed down the floor drain because such refuse clogs the sewer lines.
- Shavings and other refuse on floors should not be washed down the floor drain because such refuse clogs the sewer lines.
- An insect and rodent control program should be maintained in all animal rooms and in animal food storage areas.
- Animals transported outside of the animal facility must be contained in covered caging.
- Report all injuries and animal bites to the ULAR at 215-762-7969, your supervisor and EHRS at ehrs@drexel.edu.
- Report exposure incidents while working with animals involving rDNA, infectious substances or radiation to UBSC, RSO and EHRS. Such incidences require reporting to regulatory agencies.
- Specific instructions involving the housing, care, and maintenance of laboratory animals are available from the following sources:
  - Guide for the Care and Use of Laboratory Animals", Eighth edition 2011.
  - PHS Policy on Humane Care and Use of Laboratory Animals, revised 08/2002
  - USDA Animal Welfare Regulations (AWRs) 9 CFR, Subchapter A, Parts 1-3
  - Drexel University Guidelines for Animal Care and Use, revised 2012
  - NIH Guidelines for the use of recombinant DNA in research.

P. Visitors or Collaborators

Unauthorized persons are prohibited from entering the laboratories and the animal facilities. Visitors entering Drexel University laboratories and vivarium who will be exposed to chemical or biological agents in the course of their activities must register with EHRS at ehrs@drexel.edu.

Drexel facilities work practices are designed to protect lab and university personnel and the community. This facility may feature negative air flow, exhaust HEPA filters, exhaust fans, alarm systems and emergency electrical backup for exhaust, biosafety cabinets, incubators, refrigerators and freezers. In addition, for persons entering the facility, the following items are available: personnel protective equipment, standard operating procedures, facility verification and inspection records and facility design.

Individuals who are immunosuppressed or whose immune system or ability to fight off infection may be impaired or not effectively working (e.g., people receiving treatment for cancer, people with asthma or received transplantation) and pregnant visitors are forbidden to enter research laboratories where biohazardous materials are being used or enter animal facilities without the explicit permission from their physicians.

Each laboratory supervisor is responsible for the safety of visitors to his or her laboratory or work area, including determining that applicable training and immunization requirements have been met and that appropriate personal protective equipment is used in areas, where necessary. If applicable, proof of proper medical clearance must be submitted to the laboratory supervisor prior to a visit.

Visitors entering some of Drexel's facilities may be required to follow all procedures listed below.

- Must wear appropriate protective apparel provided by this facility, which includes:
  - fully buttoned lab coat
  - Safety glasses
  - Closed top/toed shoes or shoe covers (booties)
  - Wear protective equipment as instructed by your escort and avoid touching your face or skin with gloved hands.
- Follow escort's instructions for entry/exit procedures.
- Any packages brought into or taken out of the lab will be inspected by your escort.
- Are not allowed to open any refrigerator, freezer or incubator without permission.
- Maintenance or repair personnel must confirm with the lab that:
  - All work with live bacteria was stopped at least two hours before you entered,
  - All bacteria cultures have been locked away, and
  - All work surfaces have been decontaminated.
- Immediately before exiting the lab or the animal facility, remove booties, lab coat and gloves (in that order), and discard them in the appropriate container. WASH HANDS.
- Accidental exposure and infection can be effectively treated with antibiotics.
- If visitors are exposed to the bacteria used in this laboratory, an authorized person or your escort will decontaminate the clothing, dispose of it and disinfect exposed skin appropriately. If necessary, visitors will be sent to the nearest emergency room.
- If visitors experience any untoward effects, they must contact the laboratory and also seek care from their healthcare provider.

Q. Insect and Rodent Control

It is the policy of Drexel University that all microbiological and biomedical laboratories engage in a proactive insect and rodent control program. The current program employed at Drexel University utilizes our in-house facilities personnel and a licensed contractor. The facilities department records any noted problems on a written log. The contractor reviews the log and inspects the facility to determine if treatment is necessary.

XIII. Chemical Safety

A. Introduction

The Occupational Safety and Health Administration (OSHA) promulgated a final rule on January 31, 1990 for occupational exposure to hazardous chemicals in laboratories (The Lab Standard – 29CFR1910.1450). The basis for this standard is that laboratories typically differ from industrial operations in their use and handling of hazardous chemicals and that a different approach from the Hazard Communication Standard of 1987 is warranted.

The final OSHA standard, commonly known as the "Chemical Hygiene Plan for Laboratories," applies to all laboratories that use hazardous chemicals in accordance with the definition of laboratory use and laboratory scale as provided in the OSHA standard.

Drexel University is committed to providing a safe working environment and believes employees have a right to know about health hazards associated with their work. This Chemical Hygiene Plan (CHP)

introduces policies, procedures and responsibilities designed to develop in employees an awareness of potentially hazardous chemicals in the work place as well as the need to maintain appropriate and safe working areas and conditions. It is designed to assist employees in making knowledgeable decisions about any personal risks associated with employment at this institution. A copy of the CHP must be located in a visible area of each laboratory and be familiarized by all lab personnel. Copies are available on the EHRS website. This website also has additional information on other important subjects, such as the Hazardous Waste Management, Emergency Spill Response, Lab Safety, Bloodborne Pathogens, and Chemical Fume Hood/Biological Safety Cabinet safety.

EHRS provides training for employees, students and visitors. The training communicates the hazards of the workplace and procedures to follow to avoid accidents. This training is provided online and can be accessed thru the Safety Training link on the EHRS website. Additional site-specific training may be necessary to fully educate employees and students on the hazards associated with different work practices, protocols and procedures. It is the responsibility of the Principal Investigator or Laboratory Safety Liaison to provide this site-specific training. In any event, however, training activities must be properly documented and copies of all syllabi and sign-in sheets must be uploaded to the BioRAFT platform.

B. University Chemical Hygiene Officer (CHO)

The University Chemical Hygiene Officer (CHO) is charged with the responsibility of implementing and monitoring the chemical hygiene plan. The Chemical Hygiene Officer at Drexel University is Martin W. Bell. The Drexel University CHO can be reached at ehrs@drexel.edu.

The CHO's functions include, but are not limited to the following responsibilities:

- The development of chemical hygiene policies and procedures.
- Conduct laboratory safety inspections of all university laboratories.
- Assist PI's in complying with federal and state regulatory agencies and developing a healthy workplace environment.
- Conduct implementation and monitoring procedures in accordance with approved policies and procedures.
- Certify the performance of protective equipment.
- Monitor procurement, use, and disposal of chemicals used in the lab
- See that appropriate audits are maintained.
- Help supervisors develop precautions and adequate facilities.
- Know the current legal requirements concerning regulated substances.
- Provide general training.

C. Work Area Precautions

- Keep all work areas clean and free of clutter. Clean up the work area on completion of an operation or at the end of each work shift or class.
- Keep chemicals and equipment properly labeled and stored appropriately. Segregate chemicals as noted in Part 11 of this section. (For more information on compatible storage, refer to EHRS website).
- Do not store, handle or consume food or beverages in laboratory areas, refrigerators, or with glassware or utensils that are also used for laboratory operation.
- Seek information and advice about hazards, review SDS plan appropriate protective procedures, and plan positioning of equipment before beginning new operation.
- Leave lights on during work hours.

- Provide for containment of toxic substances in the event of failure of a utility service in an unattended operation.
- Beware of any unsafe conditions and see that they are corrected when detected. Contact the EHRS at safeheal@drexel.edu for advice.

D. Chemical Fume Hoods

Use a chemical fume hood for operations that might result in release of chemical vapors or fine powders and dust. Respirators may be necessary for work with some substances. If a substance's OSHA permissible exposure limit (PEL) can be predicted to be exceeded than a respirator will be necessary for work with that substance. Laboratory personnel and/or students must fulfill all the requirements set forth by the University's Respirator Protection program prior to working with respirators.

As a rule of thumb, use a chemical fume hood or other local ventilation device when working with any appreciably volatile substance having a TLV of less than 500 ppm.

Confirm adequate chemical fume hood performance before use by checking the airflow monitor or by placing a kimwipe on the sash to observe airflow. Keep chemical fume hood closed at all times except when adjustments within the chemical fume hood are being made. Do not store chemicals in chemical fume hoods for extended periods of time, and do not allow materials to block vents or airflow. Leave the chemical fume hood "on" when it is not in active use, if toxic substances are stored in it; or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off."

Refer to the university's Chemical Fume Hood Plan for more details concerning chemical fume hoods. Further information can be obtained by contacting EHRS at ehrs@drexel.edu.

E. Procedural Precautions

1. General

- Mouth suction for pipetting or starting a siphon is **strictly forbidden**.
- Do not smell or taste chemicals.
- Apparatus that can discharge toxic chemicals (vacuum pumps, distillation columns, etc.) must be vented into local exhaust devices or chemical fume hoods.
- Handle and store laboratory glassware with care to avoid damage. Do not use damaged glassware.
- Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments in the event that implosion might occur.
- Use equipment only for its designed purpose.

2. Process Hazard Assessment

Research personnel must perform a process risk assessment for all processes that utilize hazardous materials. The assessment is utilized to determine the level of risk associated with a specific process. The assessment evaluates the hazards associated with each task and corresponding safety controls to assist in determining whether or not the risk is acceptable. The process risk assessment can be utilized as a standard operating procedure.

The risk assessment compares the severity of the hazard to the likelihood an incident could occur. This comparison identifies the level of risk associated with the experimental process. The evaluation is performed using the following risk assessment matrix.

Severity	Likelihood		
	Unlikely (1)	Possible (2)	Likely (3)
Low (1)	1	2	3
Medium (2)	2	4	6
High (3)	3	6	9

Severity Levels are defined as:

Level	Impact to Physical Being
(1) Low	No injury, injury or ill-health requiring first aid treatment only - includes minor cuts and bruises, irritation, ill-health with temporary discomfort.
(2) Medium	Injury requiring medical treatment or ill-health leading to disability, includes lacerations, burns, sprains, minor fractures, dermatitis, deafness, work-related upper limb disorders.
(3) High	Fatal, serious injury or life-threatening, occupational disease, includes amputations, major fractures, multiple injuries, occupational cancer, acute and fatal diseases.

Likelihood levels are defined as:

Level	Event Frequency
(1) Unlikely	Not likely to occur. The event has not occurred in the PI's lab or similar lab setup. The event has not be documented in literature or safety bulletins.
(2) Possible	Possible or known to occur. The event has occurred in the PI's lab or similar lab setup. The event has been documented in literature or safety bulletins.
(3) Likely	Common or repeating occurrence. The event has occurred repetitively in the PI's lab or similar lab setup. The event has been documented in literature or safety bulletins.

Risk Level and Acceptable Criteria:

Risk Score	Risk Level	Acceptability of Risk	Recommended Actions
< 3	Low Risk	Acceptable	No additional risk control measures required. Continue to monitor to ensure the risk does not escalate to a higher level.
3 - 4	Medium Risk	Moderately Acceptable	Acceptable to carry out the work activity; however, tasks need to be reviewed to bring risk level to As Low As Reasonably Achievable (ALARA). Control measures must be implemented to reduce the risk. Supervisory oversight is required.
> 4	High Risk	Not Acceptable	Experiment cannot be performed until the risk level is reduced to the medium risk level. Control measures must be implemented to reduce the risk. Control measures must focus on elimination, substitution and engineering controls. Personal Protective equipment cannot be the sole risk control strategy. Immediate management intervention is required to ensure the risk is reduced to at least medium level prior to initiating the experiment.

Research personnel must complete the Process Risk Assessment form using the above matrix to determine the initial risk level. Medium and high-risk levels must be re-evaluated to reduce the risk to an acceptable level. The form must be approved by the PI or Supervisor of the laboratory and sent to the EHRS at ehrs@drexel.edu for final approval. The experiment cannot be initiated until final approval is provided. The assessment must be upload to BioRAFT using the Document's tab on the PIs profile page.

3. Chemical Safety Summaries

The Department of Environmental Health and Radiation Safety developed a database of Chemical Safety Summaries (CSS). The summaries can be used to complete the required process risk assessment and standard operating procedures. The CSS contain the following information:

- Chemical Name
- Hazard Rating
- Hazards
- Label Requirements
- Permissible Exposure Limits
- Personal Protection Equipment Requirements
- Precautionary Statements

The database of CSS is located in BioRAFT. As a member of the site, you can edit any CSS or add a CSS for other researchers to use. The format of any new CSS must follow the same format as the EHRS developed CSS. The CSS template can be downloaded from BioRAFT.

4. Highly Toxic and Reactive Precautions

- Review the Safety Data Sheets prior to working with any toxic or reactive chemicals. Safety Data Sheets can be accessed on the EHRS website.
- Preparations for handling highly toxic and/or reactive substances must include sound and thorough planning of the experiment, understanding the intrinsic hazards of the substances and the risks of exposure inherent in the planned process, selecting additional precautions that may be necessary to minimize or eliminate these risks, and reviewing all emergency procedures to ensure appropriate response to unexpected spills or accidents.

- Do not allow release of toxic substances in cold rooms or warm rooms, since these areas have contained re-circulated atmospheres.
- Do not use any chemicals that require ventilation in excess of your lab's capabilities. Most labs have between 6 and 12 air changes per hour. Chemicals requiring additional ventilation must be used only in hoods and glove boxes.
- Procedures involving highly toxic chemicals that can generate dust, vapors, or aerosols must be conducted in a hood, glove box, or other suitable containment device. Refer to EHRS website for hazardous chemical lists.
- When working with toxic liquids or solids, it is critical that gloves be worn to protect the hands and forearms. These gloves must be carefully selected to ensure that they are impervious to the chemicals being used and are of appropriate thickness to allow reasonable dexterity while also ensuring adequate barrier protection. Contact the EHRS at ehrs@drexel.edu for assistance on glove selection. Or refer to the Ansell Guardian Glove Selection website for assistance with selecting the appropriate glove. Click on Permeation and Degradation Database to find the appropriate glove for the chemical.

- Always inspect all personal protective equipment prior to starting any experiment and never work alone.
- When using toxic substances that could generate vapors, aerosols, or dusts, additional levels of protection, including full-face shields and respirators, are appropriate, depending on the degree of the hazard represented.
- Equipment used for the handling of high toxic chemicals must be isolated from the general laboratory environment.
- After using toxic materials laboratory personnel shall wash his or her face, hands, neck and arms prior to leaving the laboratory.
- Laboratory personnel must be specifically trained on the use of certain highly toxic and/or reactive materials. EHRS provides additional training to anyone working with any of the highly toxic or reactive materials any on the OSHA regulated materials Table Z list.

a. Perchloric Acid

- Perchloric acid is a very dangerous corrosive and oxidizing agent at high concentrations and elevated temperatures. Room temperature concentrations of 70% or less are not significant oxidizers but are still highly corrosive.
- Always review the SDS before using perchloric acid.
- Always wear appropriate personal protective equipment when using perchloric acid.
- Do not store perchloric acid with organic materials. Upon contact with perchloric acid, organic materials such as wood or cloth may ignite. Perchloric acid also must not be stored with bases, organic acids, or flammables.
- Perchloric acid spills must not be allowed to dry as they become more unstable as the acid concentrated. Also, do not leave containers uncovered. Neutralize any spill with soda ash or similar and use an inorganic absorbent to clean up the material. Do not use rags or paper towels unless wetted. Seal any cleaning materials to be discarded in a plastic bag and contact the EHRS for disposal.
- Salts of perchloric acid are also oxidizers and may be explosive.
- Any experiment involving the heating of perchloric acid MUST be done in a chemical fume hood specially designed as a perchloric acid hood. Do not use direct flame heating or oil baths. Perchloric Acid Hoods are made of stainless steel and have wash-down water spray systems.
- EHRS requires any lab using perchloric acid to write the receive and open dates on the container's label.

b. Hydrofluoric Acid (HF)

- Hydrofluoric acid is an extremely dangerous material and all forms, including vapors and solutions, can cause severe, slow-healing burns to tissue. At concentrations of less than 50%, the burns may not be felt immediately and at 20% the effects may not be noticed for several hours. At higher concentrations, the burning sensations will become noticeable much more quickly, in a matter of minutes or less. HF burns pose unique dangers distinct from other acids, it readily penetrates skin, damaging underlying tissue. The fluoride ion can then cause destruction of soft tissues and decalcification of the bones. HF can cause severe burns to the eyes, which may lead to permanent damage and blindness. The Hydrofluoric Acid Standard Operating Procedure, which is available from the Department of Environmental Health and Radiation Safety, and its MSDS must be posted prominently.
- Review the SDS before working with this material.

- Do not work alone when using hydrofluoric acid.
- For skin contact, a 2.5% calcium gluconate gel is recommended. For eye contact, a sterile solution of 1% calcium gluconate or dropper bottle of 0.5 % pontocaine hydrochloride is required to be made available. EHRS can supply any lab using HF the calcium gluconate gel.

c. Pyrophoric Organometallic Materials

- Always read the relevant Safety Data Sheet before using these materials.
- Pyrophoric chemical users must be thoroughly trained in the proper lab techniques.
- Never work alone when using these materials.
- Set up work in a laboratory fume hood or glove box and ALWAYS wear the appropriate personal protective equipment. Portable shields might be acceptable. Glove boxes are recommended when an inert or dry atmosphere are required.
- A face shield is required at any time there is a risk of explosion, large splash hazard or a highly exothermic reaction.
- Lab coats or aprons, not made of easily ignited materials such as nylon or polyester, must be worn. **Fire-resistant lab coats made from materials such as Nomex are required.**
- Minimize the quantity of pyrophoric reagents used or stored.
- Pyrophoric chemicals must be stored under an atmosphere of inert gases or under kerosene, as appropriate.
- Avoid working or storing these materials in areas near heat/flames sources, oxidizers, and water sources.
- A container with any pyrophoric residue must never be left open to the air.
- The use of smaller syringes is encouraged. If handling more than 20 ml of sample, one should use a cannula for transfer or use a 20-ml syringe repeatedly.
- The Aldrich Sure/Seal Packaging system provides a convenient method for storing and dispensing air sensitive reagents. Replace the plastic cap after each use, particularly for long term storage. The Sure/Seal septum-inlet transfer adapter must be used when repeated dispensing is necessary.

d. Piranha Solution

Piranha Solution, also known as Piranha Etch, is primarily used to remove organic residues from substrates. Because the mixture is a strong oxidizer, it will remove most organic matter, and it will also hydroxylate most surfaces (add OH groups), making them extremely hydrophilic (water compatible). Piranha solution is used frequently in the microelectronics industry, e.g. to clean photoresist residue from silicon wafers. Sometimes it is used to clean glassware, but this is discouraged, with the possible exception of sintered, or fritted, glassware.

Piranha solution is very dangerous, being both strongly acidic and a strong oxidizer. Before using Piranha, laboratory personnel should attempt more stable methods of removing stains, tars or clogs. Often, glassware will "clean itself" if simply left with a rinse of a cleaning solution present. An immediate example for a suitable substitute, prior to using Piranha, is 98% sulfuric acid.

Piranha solution be extremely energetic and may result in explosion or injury resulting from chemical and thermal burns if not handled with extreme caution. Mixing the solution is exothermic and the resulting heat can bring the solution up to 120℃, which can result in violent boiling and splashing of the acidic solution.

One must allow the solution to cool before applying any heat. Exposure to sufficient fuel, primarily organic compounds such as photoresist and isopropyl alcohol, will generate large quantities of heat and gas. If accidently inhaled, piranha vapor may irritate the respiratory tract. Both acid and base piranha are equally

dangerous when hot, although while the reaction for acid piranha is self-starting, base piranha must be heated to 60℃ before the reaction takes off. Explosions may occur if the peroxide solution concentration is more than 50%. Keep the peroxide concentration under 30%.

All Piranha solution containers including waste containers must be equipped with pressure relief caps to prevent the containers from rupturing since Piranha solutions release gas. EHRS can supply laboratories with pressure relief caps upon request, but, at this time, only size 38/439, which should fit most standard 0.05 to 4L bottles. Please make sure the caps fit the selected containment vessel before its use.

- All manipulations with Piranha solution must be done in a chemical fume hood.
- Glass or Pyrex bottles must only be used to hold Piranha solutions.
- Heavy duty neoprene or rubber gloves must be worn when handling this solution.
- Laboratory personnel must have specific training on the appropriate handling of this solution.

5. Radioactive Material Precautions

- Prior to working with any radioactive material contact the Radiation Safety Department (215-762-4050) for the current regulations concerning radioactive materials.
- Know the characteristics of the radioisotopes that are being used, including half-life, types and energies of emitted radiations, the potential for exposure, how to detect contamination, and the annual limit on intake.
- Dispose of waste radionuclides and their solutions in accordance with the University's Hazardous Waste Management Plan. Contact the EHRS at ehrs@drexel.edu concerning proper disposal procedures.
- Plan experiments to minimize exposure by reducing the time of exposure, using shielding against exposure, increasing your distance from the radiation, and paying attention to monitoring and decontamination.
- Keep an accurate inventory of radioisotopes.
- Place only materials with known or suspected radioactive contamination in appropriate radioactive waste containers.

6. Flammable Material Precautions

- Handle flammable substances only in areas free of ignition sources. Besides open flames, ignition sources include electrical equipment (especially motors), static electricity, and, for some materials (e.g., carbon disulfide), even hot surfaces. Solvent vapors can travel in air to open flames or electrical equipment.
- Check the work area for flames or ignition sources prior to using a flammable substance.
- Never heat a flammable substance with an open flame. Preferred heat sources include steam baths, water baths, oil and wax baths, salt and sand baths, heating mantles, and hot air.
- Keep containers of flammable substances tightly closed at all times when not in use.
- Use only refrigeration equipment certified for storage of flammable materials.
- Always use a chemical fume hood when using flammable solvents.

7. Nano Material Precautions

- The PI must complete a comprehensive risk assessment prior to working with any nanomaterial. The assessment must identify the tasks that may expose laboratory members to nanomaterials. The task must be inventoried and prioritized according to the potential for occupational exposure. Determinants of potential exposure may include dustiness, type of process, quantity of material handled, and duration and frequency of employee exposure.
- Handle nanomaterials in dry powder form with care to minimize the generation of airborne dust and to minimize dermal contact.
- Nanomaterials suspended in a liquid present less risk for becoming airborne than dry powder forms. However, these suspensions may present a dermal risk, especially if the nanomaterial is suspended in a solvent.
- Nanomaterials suspended in a liquid may be aerosolized during certain handling procedures (e.g. sonication).
- Nanomaterials incorporated into a solid matrix are least likely to become airborne but may pose a risk under certain circumstances like cutting, drilling, sawing or sanding the solid matrix.
- Nanomaterial experiments must be done in a manner that involves the minimum quantity for the particular experiment or process.
- Avoid handling dry nano powders on the bench top or any other open system.
- Keep nanomaterials bound in a matrix, suspend in a liquid, or sealed in a container.
- Use appropriate engineering controls. For larger processes that cannot fit in a fume hood or glovebox control emissions with properly designed local exhaust ventilation.
- Transfer nanomaterial samples in sealed, unbreakable, and labeled containers.
- Avoid generating aerosols on bench tops. Use appropriate laboratory exhaust and containment systems.
- Designate a specific space in the laboratory for nanomaterial work. This space should be isolated from other work areas and a relatively low traffic area.
- Keep laboratory doors closed at all times to prevent aerosolizing the material.
- Wear appropriate PPE when handling nanomaterials. Foot covers and chemically resistant suits may be necessary depending on the type of work. Gloves appropriate for the work must be worn. Glove selection must be determined by the type of chemicals used in the process. Refer to the Ansell Guardian Glove Selection website for assistance with selecting the appropriate glove.
- Clean all working surfaces potentially contaminated with nanomaterials at the end of each day with a HEPA vacuum and/or wet wiping. Do not dry sweep or use compressed air.
- Wash hands and arms prior to leaving the laboratory for breaks.

8. Compressed Gas Cylinders

- Compressed gas is any gas or mixture of gases exerting in a container a pressure exceeding 40.6 psia at 68 degrees Fahrenheit. Also, any flammable liquid having an absolute vapor pressure exceeding 40.6 psia at 100 degrees Fahrenheit.
- All compressed gases are considered hazardous and contain a certain volume of gas even if the gauge reads empty or zero.
- Gases MUST be stored in separate hazard classes: Flammable, Asphyxiant, Oxidizing, Corrosive, Toxic, Cryogenic, High Pressure, and Pyrophoric. Some gases combine hazard classes, such as Hydrogen has both high pressure and flammable hazards.

- Gas cylinders of all sizes, whether empty or full, must be secured in an upright position at all times. The uses of straps, chains, or a suitable stand to prevent them from falling are all acceptable practices. Contact the EHRS for securing options.
- Cylinders not in use must be capped at all times to protect the valve stems.
- Do not expose cylinders to temperatures higher than about 50 degrees Celsius. This might result in excessive cylinder pressure. Some rupture devices on cylinders will release at about 65 degrees Celsius. Small cylinders, such as lecture bottles are not fitted with rupture devices and may explode if exposed to high temperatures.
- Old/Empty gas cylinders must be returned to the supplier in a timely fashion.
- Disposal of used lecture bottles can cost anywhere from $100 to $1000 each, depending on their contents. Use only if there is no other alternative.
- Gas mixtures that contain >5.5% hydrogen in nitrogen, >2.94% hydrogen in argon, and >3.9% hydrogen in helium are classified as flammable gases. These gas mixtures must be stored and used in a vented gas cabinet with hydrogen detection.

9. Cryogenic Liquid Safety

- Be familiar with hazards associated with cryogen use.
- Review the Safety Data Sheet and the chemical safety summary for cryogenic liquids prior to use.
- Store cryogens in well-ventilated areas to prevent oxygen deficiency. Do not store or use cryogens in walk-in cold rooms, refrigerators, sealed rooms, or basements. They may not have sufficient air exchange and could become hazardously oxygen deficient. **EHRS may require oxygen level detection in certain situations.**
- Do not leave skin exposed. Do not wear metal jewelry or watches as metal can become frozen to the skin (arm, wrist, fingers, etc.).
- Always wear appropriate personal protection equipment including loose fitting insulated gloves made for cryogenic work, face shield used in combination with splash goggles or safety glasses, and appropriate apron, lab coat, or overalls. There should be no pockets exposed that liquid can get trapped inside. Rubber or latex gloves will only become brittle on contact and cotton gloves may wick up the cold liquid. Appropriate laboratory attire must be worn while handling cryogenic liquids (no open-toed shoes, no mesh shoes, no shorts, no exposed skin, etc.).
- Never allow any unprotected part of the body to touch non-insulated pipes or vessels which contain cryogenic liquids. Tissue damage may result.
- Use only approved storage vessels that have pressure relief valves. Examine containers and pressure relief valves for signs of defect, damage, neglect, or unauthorized modifications.
- Never use a container that has defects. Ask the cryogenic vendor for assistance with questions on cryogenic equipment and pressure relief valves.
- Ensure that all equipment and containers are free of oil, grease, dirt, or other materials which may lead to flammability hazard upon contact with liquid oxygen. Dirt may also cause valves to seize up.
- Select working materials carefully. Cold cryogenic liquids may alter the physical characteristics of many materials making them brittle and fail.
- It is the responsibility of the Principal Investigator to ensure lab personnel are properly trained in the safe use of cryogenic materials.
- Use a suitable hand truck for all container movement.
- Do not drop, tip, or roll containers on their sides. All cryogenic systems and Dewars must have pressure relief valves to release excessive pressure. Dewar flasks should have loose fitting lids. The pressure relief valves should be inspected regularly.
- Do not lower warm experiments into Dewars of cryogen.
- Provide proper venting for the Dewars used in experiments.

- Dewars used in experiments involving strong magnetic fields must be non-magnetic.
- Never force (i.e. use a wrench or lubricant) or modify any knob or valve on the container.
- Do not remove or interchange connections. Use only the proper connection. Do not use adapters.
- Discontinue use and contact your supplier if you experience any difficulty in operating a container valve or with the container connections.
- Use only fitted transfer tubes designed for use with the Dewar container. Damaged transfer tubes should be replaced. Do not handle transfer tubes with your bare hands as the fitting is not insulated.
- Select working materials carefully as cryogenic temperatures may alter the physical characteristics of many materials (i.e. make them brittle).
- When transferring to a secondary container, ensure the vessel is dry and do not fill the secondary container to more than 80% of capacity (60% if the room temperature is likely to be above 30oC). Pour into the vessel slowly to minimize splashing, spilling, and thermal shock to the vessel. Avoid shallow and wide-necked vessels to prevent excess evaporation and the possibility of oxygen enrichment. Never use a funnel.
- Immediately re-cap any container to prevent atmospheric moisture from entering and forming an ice plug in the opening.
- Use care in transporting cryogens; do not use fragile containers. Use a hand truck or the lowest shelf of a cart for transport of cryogens.
- When available, use service elevators for transferring unsealed containers of cryogens. Avoid passenger elevators when possible. Keep passengers off the elevator while a cryogenic liquid or gas is transported.
- Use tongs or similar devices when placing objects into or removing them from cryogenic liquids.
- Never adjust, block, or plug a pressure relief valve. The vendor is required to check the pressure relief valve before filling the Dewar.
- Avoid contact of moisture with storage containers to prevent ice plugs in relief devices.
- Periodically check container necks for ice plugs; core out ice plugs if present.
- Keep all heat sources away from cryogenic liquids.
- Cryogenic containers, whether empty or full, must be stored within the lab or an approved storage area where they are accessible to relevant personnel only. They are not to be left in the hallways where passersby may risk exposure. It is a violation of the fire code to store them in egress hallways.
- Stored Liquid Oxygen must be separated from flammables and combustibles by 20 feet or a half-hour fire wall.
- Ignition sources are not permitted near liquid oxygen or flammable cryogenic liquids.
- Keep liquid oxygen and its container clear of grease, oil, asphalt, kerosene, cloth, tar, and dirt that may contain oil or grease. These may react violently with oxygen if ignited by a spark or even a mechanical shock.
- Small amounts of cryogenic liquids may be evaporated in chemical fume hoods or another well-ventilated area.
- NEVER pour cryogenic liquids down the sink. The liquid will crack the pipes causing potentially dangerous leaks.
- Venders and Suppliers will often remove unwanted cryogenic liquids. Contact EHRS at if you need assistance.

10. Protective Clothing and Other Precautions

- Remove laboratory coats immediately upon significant contamination.

- When in the lab, appropriate footwear that completely covers the foot must be worn. Sandals, flip-flops, perforated shoes, any shoes made of canvas, or any other open-top or open-toed shoes are prohibited.
- When in the lab, pants and dresses must come down to the ankle. Shorts, short skirts and other clothing that leave sufficient skin exposed are prohibited in the lab. Shorts and short skirts may only be worn in the lab when wearing an ankle-length lab coat that covers all exposed skin.
- Disposable or special gloves, chemical aprons, goggles or eye shields must be used whenever appropriate.
- Disposable gloves must never be worn in hallways, elevators, or public areas of the university. If hazardous materials must be transported from one area to another, glove one hand to hold the product / apparatus or pushcart and use a clean ungloved hand to open doors, press buttons, etc.
- Inspect all gloves before each use. Wash them before removal. Dispose of them appropriately.
- Reusable gloves should be washed and inspected before and after each use. Gloves that might be contaminated with chemicals must not be removed from the immediate area in which the chemicals are located.
- Eating, drinking, smoking, chewing gum or applying cosmetics in the laboratory is strictly forbidden. Lunches are not to be stored in laboratory refrigerators but may be kept in the designated refrigerators outside the laboratory.
- Wash areas of exposed skin thoroughly before leaving the laboratory.
- Confine long hair and loose clothing.
- Avoid practical jokes or other behavior that might confuse, startle or distract another worker

11. Chemical Inventory

An inventory of all hazardous chemicals and non-hazardous chemicals must be prepared for each laboratory. The laboratory personnel must upload the laboratory's chemical inventory to BioRAFT using ChemTracker. Researchers can use a mobile phone to add chemicals to the inventory or bulk upload the inventory in the ChemTracker platform. The inventory must be complete and up to date. As new chemicals are obtained, the chemical inventory must be updated accordingly. Gas cylinders, cleaning supplies, and common household chemicals must also be inventoried.

Researchers are required to perform an annual reconciliation of the laboratory's chemical inventory. The reconciliation is conducted in ChemTracker.

For P.I.'s with multiple labs, each lab must have its own separate chemical inventory, specific for that room. A hard copy of the inventory must be prepared annually and posted on the laboratory's entrance door.

In addition, a separate inventory list of carcinogens, mutagens and teratogens must be prepared and posted in the laboratory for personnel to review.

12. Safety Data Sheets (SDS)

EHRS maintains an online database of SDSs in ChemTracker through the BioRAFT platform. ChemTracker will automatically assign a SDS to a chemical that is in the database when added to laboratory's inventory. The laboratory may have to manually upload a SDS for chemicals that do not match the database. It can be searched using either chemical name or location (i.e. building & room number). The SDS for each laboratory is available 24 hours a day, 7 days a week, and 365 days a year.

It is recommended, but not required, that each lab keep hard copies of the SDS for all the chemicals within the laboratory. The hard copies should be kept in a labeled binder, sorted in alphabetical order. The SDS should be kept in a visible location in the laboratory, near the entrance door to the laboratory.

Vendors and manufacturers are required by federal law to provide SDS upon request, free of charge, within a reasonable time frame. Many venders post their SDS on their webpages.

The PI/Laboratory Supervisor/Faculty Member is responsible for reviewing the SDS and recording which materials are carcinogenic, mutagenic or teratogenic. This information must be conveyed to all students and/or employees engaged in research in the laboratory, including locations used and stored within the lab. This information must be posted at the entrance to each lab in an effort to inform any individual who may need to enter that space.

13. Chemical Storage

All hazardous chemicals must be stored in clearly defined designated areas in accordance with this manual and OSHA Regulation 29 CFR 1910.1450 also known as the "Laboratory Standard". These storage guidelines must be followed when storing hazardous chemicals:

- The chemical inventory must be kept as small as possible. Any old, expired, or unused chemicals should be properly disposed.
- Do not store chemicals on top of high cabinets or shelves. Liquids, in particular corrosives or other hazardous liquids, should not be stored over 5 feet in height. The only exception is that non-hazardous liquids may be stored above 5 feet if there are space limitations. There is no height restriction for solids.
- Keep exits, passageways, areas under tables, and emergency equipment areas free of stored chemicals.
- Provide a definite storage place for each chemical and return the chemical to that location after each use.
- Do not store chemicals on bench tops and in fume hoods, except for those chemicals being used currently.
- Do not store chemicals on the floor.
- Store chemicals in a cool dry place avoiding direct sunlight.
- Ventilated storage cabinets shall be used to store extremely hazardous chemicals. The vents must be directed outside the building.
- Use chemical storage refrigerators and freezers only for chemical storage. Label these refrigerators with the following signage: "**No Food or Drink – Chemical Storage Only**"
- Safety containers must be used when transporting chemicals (i.e. carts, rubber totes, secondary containers etc.), especially outside of the lab area.
- Observe all precautions regarding the storage of incompatible chemicals.
- Dry chemicals (solid materials) shall not be stored with liquid chemicals. If stored in the same cabinet, liquids are always stored under solid chemicals.
- Separate chemicals into the following hazard classes:

    - Flammables
    - Acids
        - Organic Acids
        - Inorganic Acids
    - Bases
        - Organic Bases
        - Inorganic Bases

- Oxidizers
- Reactives
- Poisons (Toxic)
- Non-hazardous or non-regulated chemicals.

- The above hazard classes must be separated from each other. This can be accomplished by 1) placing them in different cabinets, 2) placing them on different shelves, or 3) separating them by placing the different hazard classes into separate secondary containment containers. The trays must be able to contain any spills or leaks and must be made of material compatible with the chemicals they contain.
- Other means of separating potentially incompatible chemicals are acceptable, such as the Flinn Scientific Guidelines or Control Banding. Contact the EHRS at ehrs@drexel.edu to discuss options.
- Alphabetical storage of chemicals is not allowed. This may result in incompatibles appearing together on a shelf. Chemicals should first be segregated appropriately then stored alphabetically within each hazard class.
- Chemicals classified as Irritants may be stored separately or with Non-Hazardous Chemicals.
- Weak acids or bases, in their dry form, often can either be stored as Non-Hazardous or separated out as acids or bases, unless the label specifically classifies it as "Corrosive". Any chemical specifically labeled as "Corrosive" must be separated out as an acid or a base.
- Store all flammable liquids in a grounded, flammable storage cabinet with self-closing doors.
- Do not store flammable liquids in a refrigerator unless it is an approved explosion-proof refrigerator.
- Organic Acids can be stored in the flammable storage cabinet; however, overspill containers must be used to contain any spills and to act as a means of separation.
- Acids must be stored separate from bases. Storage in the same cabinet is possible **ONLY IF OVERSPILL CONTAINERS ARE USED TO CONTAIN ANY SPILLS.**
- Separate inorganic and organic bases. These can be stored in the same cabinet. Shelves or overspill containers can be used as a means of separation.
- Separate inorganic and organic acids. These can be stored in the same cabinet. Shelves or overspill containers can be used as a means of separation. In particular, nitric acid and acetic acid must not be stored together.
- Store nitric acid, perchloric acid, and hydrofluoric acid separately from all other chemicals if possible (including from each other). Otherwise store them with other inorganic acids.
- Oxidizers must be stored in a cabinet separate from all other chemicals. Some oxidizers may cause combustible materials to catch fire on contact. Avoid storing in wood cabinets/shelves and cardboard boxes.
- Reactive chemicals must be segregated and stored appropriately i.e. flammable cabinet, explosion proof refrigerator, dedicated container etc.
- Toxic chemicals, including carcinogens, must be properly labeled; small containers should be stored together in unbreakable chemical-resistant secondary containers. These containers must be labeled either "Caution: High Chronic Toxicity," or "Cancer Suspect Agent."
- As stated above, a separate inventory list of carcinogens, mutagens and teratogens is to be forwarded to EHRS in accordance with Federal and State Regulations.
- Cylinders of compressed gases, empty or full, must be labeled, strapped or chained at all times to a wall or bench top, and must be capped when not in use.
- Oxygen and other oxidizing gases must not be stored adjacent to flammable gases (except when in use).
- Do not store flammable gases near sources of heat or ignition.
- If unable to determine the best possible storage options consult the SDS for the chemical. If further assistance is need contact EHRS at ehrs@drexel.edu.

a. Peroxide-forming chemicals

Peroxide-forming chemicals may become unstable and potentially explosive when exposed to air. These unstable peroxides may detonate with extreme violence when the material becomes concentrated by evaporation or distillation, when combined with other compounds that give a detonable mixture, or when disturbed by unusual heat, shock, or friction. As such, all peroxide-forming chemicals must have a receive date and an open date written on their labels. The chemical must be stored in airtight containers in a dark, cool, and dry area. Minimize the quantity of peroxide forming chemicals purchased and stored in the laboratory. Carefully review all cautionary materials supplied by the manufacturer or distributor prior to use. Examples of commonly used peroxide-forming chemicals include:

- Tetrahydrofuran
- Ethyl Ether
- Dioxanes
- Isopropyl Ether,
- Styrene
- Vinyl Pyridine
- 2-Propanol

Most peroxide-forming chemicals must be disposed of after 12 months, although some uninhibited peroxide-formers may only be used up to 24 hours after opening. Refer to the university's Chemical Hygiene Plan or the EHRS website for additional information.

Typical Peroxide Form Chemicals and Storage Time

Chemical Name	Unopened Container Storage Time	Opened Container Storage Time
Isopropyl Ether	18 months	3 months
Cyclohexanol	18 months	12 months
Dioxanes	18 months	12 months
Diethyl Ether	18 months	12 months
Tetrahydrofuran	18 months	12 months
2-Propanol	18 months	12 months

Perchloric Acid is another potentially explosive chemical which should be disposed after 12 months. While not as potentially hazardous as other peroxide-formers, older containers of 2-Propanol should be handled with care. To track how old the chemicals are, all labs are required to write the receive date and open date on the containers of peroxide-formers, unless there is an expiration date already present.

DO NOT handle any peroxide forming chemical if there are signs of crystal growth or precipitation. Immediately contact EHRS at 215-895-5919 or at ehrs@drexel.edu if this occurs and leave the area.

14. Labeling

a. Chemical Container Labels:

OSHA requirements for labeling under the Chemical Hygiene Plan will be the same as those defined in the hazard communication standard 1910.1200 and 1900.1450. Therefore, all containers in the workplace (including secondary containers (beakers, Erlenmeyer flasks, cap bottles, etc.) must contain the following information:

- Identity of the substance.
  - Full chemical name.
  - Abbreviations and/or symbols are not acceptable.
- Signal word – Danger or Warning.
- Hazard Statement – flammable, oxidizer, irritant, toxic, etc.
- Responsible party.

All labels must be prominently displayed and legibly written (printed) in English and other language as appropriate for employees. It is the responsibility of the principal investigator to inspect all incoming shipments of containers of hazardous chemicals to ensure that they bear labels with the appropriate information.

The names of buffers (PBS, TBS, HEPES, Tris, etc.) may be abbreviated, as long as a Key or Legend stating the full name is placed in a clearly visible location in the laboratory, preferably by the lab entrance. Abbreviations, formulae, or symbols of commonly used chemicals may also be written on secondary containers, provided they are included on a key or legend visibly posted in the lab.

Sample vials too small to write the full chemical name and hazard information on may be coded. Codes may be printed up on a key or legend and placed in a visible location at the work area for this purpose. Otherwise all code keys must be written clearly and legibly in the laboratory notebook. Signage is required at all workstations denoting both that the code key is located in the notebook and the location of the notebook itself. The laboratory notebook must be kept in a visible area and returned there at the end of the experiment or the end of the day.

It is recommended that the date be placed on all chemical containers when they are received and opened. This is required for any peroxide-forming chemicals. For any solutions prepared by the laboratory personnel (i.e. buffers, media, and dilutions), it is also recommended to add the date it was made to the container's label.

If a container received from the chemical distributor is improperly labeled, laboratory personnel must contact the EHRS at ehrs@drexel.edu who will notify the vendor for correction, and the receiving department for informational purposes.

Portable or secondary containers used for purposes of transferring hazardous material from a labeled container for immediate and complete use by an investigator or his /her technicians or research staff or student do not require labeling. However, if the transferred hazardous material is to be used by other research personnel/student, or is not immediately used, it is the responsibility of the investigator/lab supervisor/faculty member/student/lab technician for whom the chemical material was first intended, to properly label the portable container.

b. Laboratory Labels

All laboratory entrance doors must be labeled as follows:

- NFPA diamond. Laboratory personnel shall fill in the diamond with the highest hazard number pertaining to their laboratory.
- Biohazard label and appropriate Biosafety Level (if applicable).
- UV Light label (if applicable).
- Radiation Hazard Label (if applicable).
- Emergency contact information. The information must include a name and number to contact in the event of an emergency. It must be clearly visible and placed on each outer laboratory door

Additional warning labels as applicable, i.e. "carcinogen in use", "water reactive materials", "inhalation hazard, respiratory protection required in this area", "high noise, hearing protection required in this area", etc.

c. Chemical Storage Labeling

All cabinets, shelves and refrigerators containing chemicals (including the cleaning supplies) must be labeled with the appropriate warning label (Flammable, Acids, Bases, Oxidizers, Reactives, Poisons (Toxic), Non-Hazardous, and/or NFPA Diamond).

Refrigerators and freezers used for chemical storage must be labeled with appropriate hazard warnings and with the signage: "NO Food or Drink – Chemicals Storage Only." Any refrigerator used of food or drink storage must be label as such and remain outside the laboratory. Laboratory microwaves and ovens must also have "No Food or Drink" signs.

Biohazard labels must be applied to all appropriate areas, such as Biological Safety Cabinets and refrigerators. Radiation hazard tape or labels must be applied to all applicable work and storage areas. UV Light warning labels must be placed on any device that can generate ultra-violet light, such as Biological Safety Cabinets.

Old and obsolete labels in the lab must be removed or defaced.

15. Receiving Chemicals

Laboratory personnel must inspect all chemical packages delivered to the laboratory. Packages that are damaged or leaking must not be accepted from the delivery person. Do not open any damaged or leaking packages. Contact EHRS at ehrs@drexel.edu if you have damaged or leaking package.

All chemicals delivered to the laboratory must have an SDS present in the package. Manufacturers are required by OSHS to provide the SDS with every chemical product. The PI must review the SDS with all the laboratory members prior to using the chemical. Contact EHRS at ehrs@drexel.edu if the package did not contain the SDS.

All newly delivered chemicals must be immediately added to the laboratory's inventory. The PI must send an email (ehrs@drexel.edu) to EHRS indicating the arrival of the new chemical. The information is used to update the online SDS system.

F. Engineering Controls

1. Laboratory Ventilation

All laboratories are designed with mechanically generated supply and exhaust air. All laboratory exhaust air is ducted and exhausted to the outside. The system does not return contaminated air back to the laboratory.

Most Laboratories have minimum of eight (8) to ten (10) air changes per hour during occupied times and six (6) air changes per hour during unoccupied times. The control to determine occupied versus unoccupied is determined by occupancy sensors not time. Some laboratories do not have the ability to reduce the airflow. In these spaces, the number of air changes per hour remains the same during occupied and unoccupied times.

Laboratories are maintained under negative pressure in relation to the corridor or other less hazardous areas. In general, the laboratory supply is ten (10) to twenty (20) percent less than the exhaust. This creates the negative pressure in the space in relation to the corridor. The reason for the negative pressure is to contain any hazardous materials or fires in the space. Clean rooms and tissue culture rooms requiring positive pressure have a positive pressure entry vestibule which allows the main laboratory to have negative pressure in relation to the vestibule.

Propping open the laboratory entrance doors will disrupt the pressure inside the laboratory. As such, all laboratory doors must remain closed at all times.

Newly renovated laboratories are equipped with pressure monitors. These monitors are installed at the entrance to the laboratory. The monitor displays the pressure reading in the laboratory. The monitor will alarm if the pressure in the laboratory goes from negative to positive pressure. Laboratory members must stop all activities if the pressure monitor is alarming.

2. Chemical Fume Hoods

Work involving chemicals with high vapor pressures or low threshold limit values (TLVS) must always be done within a chemical fume hood.

The chemical fume hoods are inspected annually and certified by a third-party vendor. All chemical fume hoods must meet specific certification criteria to be used. The certification tests the containment and face velocity of the chemical fume hood. The chemical fume hood must capture, and exhaust smoke emitted into the hood. The face velocity must be between 80 and 120 feet per minute with a sash height between 15 and 21 inches. The ideal face velocity is 100 fpm with a sash height of 18 inches. Any hood not providing 80 to 120 linear feet per minute of airflow or manufactures recommended value must not be used. If chemical fume hoods do not meet specifications, they will be taken out of service immediately and are not to be used until the hood has met the criteria for certification. Refer to the University's Chemical Fume Hood Policy on the Laboratory Safety page of the EHRS website.

In some laboratories, there are low exhaust flow chemical fume hoods. These hoods have face velocities in the range of 60 feet per minute. The same certification criteria apply to these hoods with the exception of the face velocity test. The velocity must be within the range of the manufacture's design criteria.

An audible and visual air flow alarm is present on the face of each chemical fume hood. This alarm indicates whether or not the chemical fume hood has sufficient exhaust. The alarm will provide an audible signal and

a red light when the exhaust is not sufficient. In addition, some chemical fume hoods have sash position alarms to prevent the personnel from working with the fume hood sash in the full open position. The sash must be returned to the eighteen (18) inch mark to clear the audible and visual alarm.

Work must immediately stop if the air flow alarm is activated. Contact EHRS at 215-895-5919 or via email at ehrs@drexel.edu.

3. Local Exhaust Ventilation

Many laboratories use equipment that can generate airborne contaminants but cannot be used within a chemical fume hood. Examples include gas chromatographs, ovens, and vacuum pumps. Other types of local exhaust ventilation systems may be required to control contaminants generated by these operations. Such systems must have a separate exhaust duct and must not be installed without approval from EHRS. Consult EHRS before installing, modifying, or purchasing laboratory ventilation equipment to verify that it conforms to all relevant safety, building, and fire code regulations.

4. Eyewash Station and Safety Shower

Eyewash stations and safety showers are essential in every laboratory. These stations must be located within 25 feet and/or 10 seconds of unobstructed path of the laboratory operation. Eyewash stations and showers should be located within the laboratory, especially if corrosive or injurious chemicals, strong irritants, or toxins that can be absorbed through the skin are present, or if the lab is subject to BSL-2 (or higher) regulations.

Regulatory standards insist that the eyewash station be hands-free or automatically operated. Drench hoses, sink faucets or showers are not acceptable eyewash substitutes. Facility limitations may affect these requirements. Locations of emergency eyewash stations and safety showers shall be identified with a highly visible sign.

Eyewash stations must be inspected once a week by the laboratory personnel. The weekly test must be documented, and the record must be maintained by the Principal Investigator/Faculty Member/Laboratory Supervisor. EHRS recommends keeping the record near the eyewash station. Inspection forms can be obtained by contacting EHRS at ehrs@drexel.edu.

EHRS certifies eyewash stations and safety showers annually. The certification record is uploaded to BioRAFT and associated with the specific space.

G. Administrative Controls

The safe operation and compliance of each laboratory is the responsibility of the respective PI/Faculty Member/Laboratory Supervisor, while the overall responsibility for the enforcement of the chemical hygiene plan rests with the EHRS. Policy and implementation procedures pertaining to the CHP require approval by the EHRS.

The administrative controls enforced at the university include, but are not limited to:

- Restricted access and proper signage on all entrances leading to areas containing agents that may be immediately dangerous to life or health.
- Proper labeling on laboratory doors, cabinets and containers containing potentially hazardous materials.

- The observation of Standard Universal Precautions when working with blood and bodily fluids of humans and animals, recombinant DNA or potentially pathogenic bacterial or viral agents.
- The contents of the lab safety manual and the radiation safety manual and all applicable federal and state regulations established to protect human health and the environment.
- If a chemical is produced for another user at Drexel University or at another facility, the researcher shall comply with the Hazard Communication Standard 29 CFR 1910.1200, including the requirements for preparation of material safety data sheets and labeling.
- Environmental monitoring is required in all laboratories using the chemicals listed in Table Z-1 and Z-2 (29 CFR 1910.1000) that would generate anticipated exposures in excess of the permissible exposure limit (PEL) or the threshold limit value (TLV).
- Chemical spill response must be performed in accordance with this manual. Laboratory personnel are responsible for cleaning up spills of materials that are not acutely hazardous or in quantities of less than 500 ml. Laboratory personnel are responsible for containing and reporting larger spills and/or spills of acutely hazardous materials such as phenol, mercury, etc.
- Procedures for containing and/or cleaning chemical spills have been developed in accordance with OSHA guidelines and are described in Section XVI.
- All chemical spills greater than 100 milliliters must be reported to EHRS immediately at ehrs@drexel.edu or at 215-895-5919.
- Appropriate spill kits must be maintained in each lab or in centralized common areas accessible by all lab personnel. It is the responsibility of the PI/Faculty Member/Laboratory Supervisor to ensure that ample spill materials are available and that laboratory personnel are familiar with locations and use of these materials.

H. Personal Protection Equipment (PPE)

All laboratory personnel and visitors must wear the required PPE. You will be removed from the laboratory if you are not wearing the required PPE. Laboratories that continually disregard the required PPE may be closed for a time period determined by EHRS.

Know the locations of PPE and how to obtain additional materials when necessary. If appropriate PPE is not readily available do not initiate experiments involving hazardous chemicals.

The Principal Investigator shall provide proper personal protection equipment for all personal in the research laboratory. The PI must provide the training on appropriate use and limitations as well as the locations of all PPE.

Faculty Members/Laboratory Supervisors shall require students to obtain the appropriate PPE prior to commencing any laboratory activities. If proper PPE is not available, no lab activity can proceed. For proper PPE selection contact the EHRS at ehrs@drexel.edu.

1. Eye Protection

Appropriate eye protection is worn at all times by all persons in laboratory. Eye protection consists of safety glasses with side shields, splash goggles or face shield, or full-face respirator. Chin length face shields are

to be worn to prevent splashes or sprays of blood, infectious materials, or hazardous chemicals when there is a potential for eye, nose, or mouth contamination.

Eye protection is required whether or not one is actually performing experimental operations and must be worn by all lab personnel and visitors. Prescription eyeglasses and contact lenses are not appropriate protection.

Laboratory personnel may remove the eye protection if work involves viewing samples or specimens through a microscope.

2. Body Protection

Appropriate body protection is worn at all times by all persons in the laboratory. Body protection consists of a laboratory coat, pants, shirt, and closed top/toed shoes. Clothing that exposes large areas of skin is not permitted. Shorts, skirts, and short pants that expose large areas of skin are prohibited from being worn in the laboratory. Open top/toed shoes, flip flops, perforated shoes, sandals, and cloth shoes do not provide protection from hazardous materials and are prohibited from being worn in the laboratory. Shoes must cover the entire foot.

Personnel working with flammable, pyrophoric or reactive chemicals must wear flame-resistant laboratory coats (e.g. Nomex®). Laboratory coats must not be worn in the hallways or common spaces outside the lab.

3. Other Personal Protective Equipment

a. Gloves

Laboratory personnel are required to wear appropriate gloves when there is a potential for direct contact with blood, hazardous chemicals, infectious agents, or other hazardous materials.

Select gloves appropriate for the task. Gloves protect differently for each chemical. Wearing the wrong type of glove can be more hazardous than wearing no gloves at all. If the chemical seeps through, the glove can hold it in prolonged contact with the wearer's skin. For more information concerning glove selection contact EHRS at ehrs@drexel.edu. The EHRS website has a link to the AnsellGuardian glove selection chart. This can be used to identify the appropriate gloves for the task.

- Use disposable gloves when dexterity is needed and the contamination warrants one time use.
- Use heavy duty gloves when the hazard requires it. For example, use butyl gloves (pictured to the right) to handle 70% nitric acid or acetone. The permeation breakthrough time for this butyl glove is greater than 480 minutes. Disposable nitrile gloves have a permeation breakthrough time of less than 10 minutes. Therefore, must not be used when handling acetone or nitric acid.
- Use puncture or cut resistant gloves when handling sharp objects.
- Use insulated gloves when handling cryogenic or hot materials.
- Wash hands prior to wearing gloves.
- Double glove to provide multiple lines of defense when working with highly toxic or multiple hazard materials.
- Inspect and change gloves frequently to avoid exposure. Wash hands with soap and water immediately after removing gloves.

Gloves must only be worn in the lab and taken off before leaving, especially when handling infectious material. If transporting hazardous materials from one are to another, glove one hand to hold the product/apparatus or push the cart and use a clean, ungloved hand to open doors, press buttons, etc. Wash hands immediately after removing the gloves.

b. Respiratory Protection

Use appropriate respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls. The Principal Investigator must perform a risk assessment to determine the need for respiratory protection. Assistance with this assessment can be obtained by contacting EHRS at ehrs@drexel.edu.

The odor threshold for many chemicals is much lower than the permissible exposure limit, and in many circumstances, is a great indicator of exposure. Refer to the Odor Threshold Chart in this manual and the OSHA PEL list to determine if a respirator is required.

When the use of respirators, in research laboratories, is necessary to maintain exposure below the permissible exposure limit (PEL), the respirator will be provided by the PI at no cost to the employee. EHRS will provide students, at no cost, with respirators when the use is necessary to maintain exposure below the permissible exposure limit (PEL).

The proper respiratory equipment can be obtained by contacting EHRS at ehrs@drexesl.edu. The respirators shall be selected and used in accordance with the requirements of OSHA's Respiratory Protection Standard (29 CFR 1910.134) and ANSI Z88.2-1969. Training, an annual physical and pulmonary function test will be required for all individuals requiring the use of respirators in accordance with OSHA's standards on respiratory protection 29 CFR 1910.134. Proper respiratory equipment includes the following types:

- Air Purifying Respirators (APR)
    - Tight fitting dust/mist - N95, R95, P95, N100, R100, P100
    - Tight fitting Half-Faced
    - Tight fitting Full-Faced
    - Powered Air Purifying Respirator (PAPR)
- Supplied Air Respirators (SAR)
    - Self-Contained Breathing Apparatus (SCBA)

The requirements set forth in the University's Respirator Protection Policy must be fulfilled prior to performing work with a respirator. Contact EHRS at ehrs@drexel.edu to enroll in the program. Do not got to the local hardware store to purchase a respirator for use. You may purchase a respirator that is inappropriate for the hazard.

I. Personal Exposure Monitoring

Upon request of the laboratory personnel, the University CHO will review laboratory work practices and normal operations in an effort to determine if university employees are at risk of exposure to regulated substances in accordance with the OSHA permissible exposure limits and action levels as outlined in 29 CFR 1910.

Initial and annual surveillance monitoring (environmental and personal) will be conducted whenever exposures to hazardous agents are anticipated to exceed the action level, the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLV) or OSHA'S PEL. Additionally, monitoring will be conducted when:

- Past monitoring has indicated elevated exposures.
- When requested by an employee or student.
- When an employee or student experiences signs or symptoms of overexposure.
- When laboratory operations change such that and area previously identified as not expected to have significant exposure would now be expected to have elevated concentrations of hazardous agents.

All personal exposure monitoring activities (including sampling, analysis and record keeping) will be performed in accordance with OSHA requirements and/or NIOSH recommended practices. In addition, the results of the sampling will be uploaded to the specific laboratory in BioRAFT.

J. Occupational Health Services

Drexel University offers occupational health services to all employees. Employees are provided at orientation the Guideline for Occupational Health Services form. This form determines whether or not occupational health services are required. The purpose of the services is to create a baseline analysis of the employee's health prior to working with specific agents or chemicals. Services will include appropriate vaccinations, baseline medical monitoring and physicals as required under federal and state regulations for those individuals who have a potential for exposure. Additional medical services and consultations may be recommended by EHRS prior to the approval of protocols involving the use of extremely hazardous or pathogenic agents.

The service is provided at several locations:

Service Provider	Address
Concentra Occupational Health Center City	219 North Broad Street, Philadelphia, PA 19107 1st Floor 215-762-8525
Concentra Occupational Health Navy Yard	4050 S. 26th Street, Philadelphia, PA 19112 215-467-5800

In addition to the initial and annual services, the healthcare services provide support for employee injuries. Employees with life threatening injuries must call 911 for immediate medical care. Employees with non-life threatening injuries must seek medical attention at one of the service provider locations.

All injury-related examinations and consultations are performed by or under the direct supervision of one of panel of licensed physicians without cost to the employee, without loss of pay, and at a reasonable time and place. The employee is sent for medical evaluation:

- Whenever signs and symptoms associated with a hazardous chemical develop.
- When environmental monitoring reveals an exposure level routinely above the action level.
- Whenever an event takes place in the work area such as a spill, leak, or explosion resulting in hazardous chemical exposure.

The employee's supervisor, Risk Management or EHRS will provide the following information to the physician:

- Identity of the hazardous chemical(s) to which the employee may have been exposed.
- A description of the conditions under which the exposure occurred, including quantitative exposure data (if available).
- A description of the signs and symptoms of exposure.
- A copy of the MSDS for the chemicals involved.

The physician will provide a written opinion that will not reveal specific findings of diagnosis unrelated to the exposure but will include:

- Any recommendation for further medical follow-up.
- Results of the medical examination and any associated tests.
- Any medical condition that may be revealed in the course of the examination that may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace.
- A statement by the physician that the employee has been informed of the consultation and examination results and any medical condition that may require further examination or treatment.

All such medical records will be kept for at least as long as the employees affected are employed. OSHA requires some records to be kept for 30 years beyond the employee's time of employment. The laboratory standard requires that all records be maintained of all exposure evaluations, medical consultations, and reports and that those records be maintained in accordance to 29 CFR 1910.1020. This section requires those records to be maintained for at least 30 years and describes the accessibility procedure for maintaining the records.

Contact EHRS at ehrs@drexel.edu or additional information about occupational health services.

XIV. Radiation Safety

A. Introduction

The Radiation Safety Program at Drexel University is administered by the Radiation Safety Office (RSO) at the direction of the Radiation Safety Committee. The policies and procedures, which make up the radiation safety program, are contained in the university's Radiation Safety Manual. Please refer to the manual for the current policies and procedures.

The use of radioactive materials is regulated by various agencies including the U.S. Nuclear Regulatory Commission and the Pennsylvania Department of Environmental Protection. Both of these agencies issue licenses, which specifically authorize the use of various radionuclides. The licenses also have conditions and limitation to which Drexel University must adhere, as well as published regulations.

Investigators who desire to use radioactive materials in their laboratory need to apply for authorization from the Radiation Safety Committee. The Committee reviews the training and experience of the investigator with regard to the use of radioactive materials, the proposed use of radioactive material to determine that the work in within the conditions and limitation of the federal and state licenses, that the facilities and equipment are adequate to perform the work safely, and that the procedures are conducted to minimize the risk of the exposure and containment. Applications are available on the Forms page on the Radiation Safety Office webpage and must be submitted to the RSO. Investigators that have been approved to use radioactive

materials in their laboratory have the responsibility for adhering to any conditions of approval and for complying with the radiation safety program.

The RSO provides a variety of services, including:

- Monitoring radiation exposures, including surveys, personal monitoring, and bioassays.
- Investigating spills, incidents, and other unusual events involving radioactive material.
- Investigating overexposures.
- Conducting an ALARA program to assure the radiation exposures are kept as low as reasonably achievable.
- Maintaining an inventory of all radioactive material at university.
- Disposing radioactive waste.
- Surveying packages of radioactive material upon receipt.
- Transporting radioactive material in compliance with U.S. Department of Transportation requirements.
- Auditing/inspecting laboratories for compliance with the radiation safety program.
- Conducting independent surveys of laboratories.
- Training radiation workers through short courses, in-services, and meetings.
- Approving users and uses of radioactive materials.
- Maintaining requisite records.

Contact the RSO at 215-895-5919 or via email at ehrs@drexel.edu to request personal monitoring (film badges and ring TL dosimeters), to report accidents, incidents, or spills, to request services, or if there is any question as to the proper procedures.

For emergencies after normal business hours, contact the emergency operator who will contact the radiation safety personnel on call.

B. Radioisotope Licensing

The Radiation Safety Office is responsible for issuing licenses to investigators, monitoring the procedures for safety and health involving all individual uses, monitoring isotope records, and disposal of all radioactive material. Please consult Radiation Safety Manual for information concerning issuance of new, modification or transfer licenses. Blank license forms for applications, modification, or transfer memos are available from the Radiation Safety Office.

C. Radiation Warning Signs

Radiation warning signs must be placed on the doors of laboratories using radioactive materials. Further, all laboratory equipment such as refrigerators, sinks, centrifuges, etc. and containers used for laboratory procedures or waste involving radioactive material must be plainly marked with radiation hazard warning labels.

D. Radiation Work Areas

Work areas specifically for radioactive materials, must be established in the laboratory. Absorbent paper with a non-porous backing and spill trays must cover the work surfaces to contain spills and reduce the spread of contamination.

E. General Radiation Safety Procedures

The RSO created the following general safety procedures for work involving radioactive materials. These general radiation safety procedures must be posted in the laboratory adjacent to the radiation work area. The most current version of these procedures can be obtained by contacting the RSO at 215-895-5919 or via email at ehrs@drexel.edu.

- Eating, drinking, application of cosmetics, manipulation of contact lenses is NOT permitted.
- Smoking or chewing of tobacco products are NOT permitted.
- Do not store food or drinks for human consumption within the laboratory.
- Mouth pipetting is NOT permitted.
- Careful experimental planning, including dry runs, shielding considerations, source handling tools, contamination control and monitoring must be performed to minimize exposure and chance of spills or other incidents.
- Wear laboratory coat while in the laboratory.
- Wear disposable gloves and change them frequently.
- Use plastic backed absorbent paper on all work areas where radioactive materials will be used. Use drip trays where practical.
- Label radioactive work areas and containers of radioactive material with radioactive warning tape.
- Use appropriate (e.g., shielded, labeled) containers for storing or carrying radioactive material.
- Seal containers of radioactive material when vortexing, centrifuging and incubating.
- Use a secondary trap flask in series with collection flask for vacuum aspiration.
- Wear radiation monitoring badge(s) if assigned.
- Do NOT wear another lab member's radiation monitoring badge. If your badge is missing contact the Radiation Safety Office at 215-895-5919 or vis email at ehrs@drexel.edu.
- Post the following notices in the laboratory:
  - NRC Form 3 – "Notice to Employees"
  - General Radiation Safety Procedures
  - Emergency Procedures
- Label the laboratory and equipment, as applicable, with "Caution Radioactive Material" sign.
- Maintain record of receipt, use and disposal of radioactive material.
- Monitor hands, shoes and clothing frequently.
- Wash hands after using radioactive material, before eating or smoking, and when leaving the work area. Survey yourself (hands, body, feet) and work area before leaving the laboratory for lunch, breaks and/or the end of the day; and after each high-level use (i.e. Alliquoting from stock solution) of radioactive material.
- Dispose waste according to guidelines as found in the Radiation Safety Manual.
- Follow the procedures for receiving radioactive material packages.
- Use Plexiglas shielding where practical and appropriate when manipulating 32P or other high energy beta emitter.
- Use approved fume hoods or glove boxes when required in licensing conditions to control possible airborne contamination.
- Prevent unauthorized access to radioactive material by challenging unauthorized individuals, locking radioactive material in refrigerators, freezers or storage cabinets, or locking the laboratory when no one is physically present.
- Follow the approved protocol and any conditions of authorization.
- The RSO must be notified in the event of:
  - Personnel contamination;
  - Any accident resulting in direct exposure to personnel;

- Unexpected loss of RAM to air or sewer; or loss of RAM

F. Pregnancy Protection

State and federal regulations limit the radiation dose to the embryo/fetus of an occupationally exposed declared pregnant woman to 0.5 rem (500 millirem) for the entire gestation. A declared pregnant woman is defined in the regulations as "a woman who has voluntarily informed the licensee, in writing, of her pregnancy and the estimated date of conception."

The dose limit is only for occupational exposures. Any radiation exposure received as a patient from medical diagnosis or treatment, and exposures received from natural background radiation are not controlled by this limit.

The woman must provide the declaration of pregnancy in writing to impose the more restrictive limit. The declaration of pregnancy is strictly voluntary. In effect, a pregnant woman has the choice of declaring her pregnancy, thereby imposing a more restrictive dose limit to her embryo/fetus. To comply with the more restrictive radiation dose limits, the university may require the use of additional protective equipment (i.e. additional shielding, lead aprons, etc.), increased monitoring (i.e. extra film badges, pocket dosimeters, etc.), or re-assign duties. Note that most activities involving exposure to radiation at the university result in annual radiation exposures of less than 500 millirem.

To comply with this regulation, the Radiation Safety Office has implemented the following policy and procedures:

- The pregnant woman who wishes to impose radiation dose limits for her embryo/fetus must provide a written declaration to the Radiation Safety Officer at ehrs@drexel.edu. The form can be obtained on the Forms page on the Radiation Safety Office website.
- Declaration of pregnancy is strictly voluntary.
- A pregnant woman who plans to declare her pregnancy is encouraged to do so promptly upon discovering her pregnancy so that the appropriate precautions can be taken early in the gestation period.
- The declaration of pregnancy will be kept confidential. The declaration of pregnancy will only be disclosed to university employees with a legitimate need to know (i.e. immediate supervisor).
- A declared pregnant woman may "undeclare" her pregnancy. The intent of the regulation and this policy is to give the pregnant woman the right to choose whether or not to impose dose limits. She may revoke her choice but her right to choose is irrevocable.
- A pregnant woman may seek recommendations from the RSO to reduce radiation exposure to her embryo/fetus without declaring her pregnancy.
- Any woman may request additional information on the risks associated with radiation exposure to the embryo/fetus from the RSO.
- The declared pregnant worker will notify the RSO of the end of her pregnancy so that the special precautions can be terminated.
- The radiation dose limit to the embryo/fetus of a declared pregnant woman is 0.5 rem (500 millirem). The radiation dose limit applies only to occupational exposure of the declared pregnant woman. It does not apply to radiation exposure from medical diagnosis or treatment, nor does is apply to background radiation exposures.
- Restrictions may be imposed to prevent radiation exposures from exceeding 500 millirem during the gestation. These restrictions may include a temporary change in work assignments, the use of additional protective equipment, and increased monitoring.

- If the embryo/fetus radiation exposure has exceeded 450 millirem before the pregnancy is declared, a dose limit of 50 millirem will be in effect for the remainder of the pregnancy.

Contact the Radiation Safety Office at 215-762-4050 or via email at ehrs@drexel.edu for additional information regarding pregnancy protection.

G. Emergency Procedures

1. Radioactive Material Spills

Because any response depends upon the nature of the incident, radioactive spills have been categorized into minor and major spills.

a. Radioactive Minor Spills

If all of the following are true, an incident can be considered minor:

- The nature and potential hazards are known
- There is no contamination of personnel
- One or two people can clean up the incident in about an hour
- There is no release of radioactive material into unrestricted areas
- There is no airborne radioactive material
    - There are no injuries (e.g., lacerations from broken glass) except where radioactive material is not involved and medical attention is not required
    - There is no potential uptake of radioactive material

In the event of a minor spill take the following steps:

- **Notify** all other persons in the room or area that a spill has occurred.
- **Prevent spread of contamination** by covering the spill with absorbent paper.
- **Decontaminate** the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
- **Survey** the area and all contaminated and potentially contaminated individuals with a G-M survey meter. Survey for removable contamination using wipe samples.
- **Report** the incident to the Radiation Safety Office by telephone.

b. Radioactive Major Spills

If any of the following are true, an incident should be considered major:

- The nature or potential hazard cannot be ascertained
- Personal contamination (skin or clothing; contamination of personal protective equipment, e.g., lab coats is not personal contamination)
- The cleanup will take more than two people or more than an hour to perform.
- There is a release of radioactive material into unrestricted areas.
- Airborne radioactive material is generated.

- Injuries which might involve radioactive material (e.g., laceration from contaminated glass)
- Injuries which require medical attention
- There exists the potential for an uptake of radioactive material.
- Fire or explosion
- Evacuation of the room or building is necessary

In the event of a major spill take the following steps:

- **Clear the area**: notify all persons not involved with or near the spill to vacate the room.
- **Prevent spread of contamination:** cover the spill with absorbent paper. Do NOT attempt to clean it up. Assemble all potentially contaminated personnel near the room entrance.
- **Close the room**: prevent entry into the room.
- **Call for help**: Immediately contact Radiation Safety.
- **Decontaminate personnel**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly with lukewarm water and then washed with mild soap and lukewarm water.

For more information on the university radiation safety program, consult the university's Radiation Safety Manual.

2. Radioactive Material Accidental Exposures

Laboratory personnel must immediately contact the RSO at 215-762-4050 or the Public Safety Dispatch Center at 215-895-2222 in the case of accidental exposure to radioactive material. The laboratory member must provide the type of radioactive material involved and the location of the material.

H. Package Receipt

Most packages containing radioactive material must be surveyed for contamination upon receipt. NRC regulations require formal procedures for safely opening packages containing radionuclides. The initial package check-in is performed by the RSO. Refer to the Radiation Safety Manual for details or call 215-895-5919 or email ehrs@drexel.edu.

I. Radioactive Waste Disposal

Disposal of radioactive material must be performed in accordance with federal, state and local regulations. Refer to the university's Radiation Safety Manual for the appropriate radioactive waste disposal procedures.

For additional information concerning waste disposal, contact the RSO at 215-895-5919 or via email at ehrs@drexel.edu.

J. Records of Radioactive Material Usage

All licensees of radioactive material are required to submit quarterly reports of receipt and disposition of radionuclides in accordance with the instructions contained in the university's Radiation Safety Manual.

XV. Laser Safety

The Laser Safety program provides individuals using lasers information on laser hazards, laser-related policies and procedures and recommendations for the safe use of lasers. Much of the information contained in the program is based on the American National Standards Institute's (ANSI) standard Z136.1-2000, American National Standard for Safe Use of Lasers. The ANSI standard is the accepted standard for laser safety in the United States.

The laser safety program's primary objective is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) reaches the human eye or skin. Additionally, the program is designed to ensure that adequate protection against collateral hazards is provided. These collateral hazards include the risk of electrical shock, fire hazard from a beam or from use of dyes and solvents, and chemical exposures from use of chemicals and vaporization of targets.

A. Responsibilities

1. Laser Safety Officer (LSO)

- Administer the overall Laser Safety Program.
- Maintain a current inventory of Class 3b and 4 lasers.
- Accompany outside inspectors/regulators on laser safety inspections.
- Perform laser hazard analyses.
- Perform laser safety audits to ensure compliance with the policy.
- Make recommendations to improve laser safety.
- Restrict or terminate use of lasers that present an imminent danger or excessive hazard.
- Make recommendations for selection of proper personnel protective equipment.
- Investigate laser accidents and near misses.

2. Principal Investigator (PI)

- Complete a Laser Registration Form for each Class 3b or 4 laser and send the forms to the LSO at ehrs@drexel.edu.
- Ensure that standard operating procedures (SOPs) are written for all Class 3b and 4 laser activities. These procedures, which must contain the name and contact information for the PI, must sent to the LSO for final approval. The procedure must be posted next to the laser and uploaded to the documents section of the laboratory in BioRAFT.
- Comply with the safety requirements outlined in this Laser Safety Policy.
- Supervise the safe use of lasers in the laser environment.
- Classify and label appropriately all lasers under his/her control.
- Establish and maintain a current list of those personnel approved to operate each Class 3b or 4 laser under their supervision and provide a copy of the list to the LSO.
- Complete the applicable online Laser Safety course at the interval specified in this manual.
- Immediately notify EHRS at 215-895-5919 or via email at ehrs@drexel.edu in the event of a suspected overexposure to the output beam from a Class 3b or 4 laser.
- Provide laser operators with training in the alignment, standard operating and administrative procedures. This training must be documented and uploaded to BioRAFT under the Documents section of the platform.
- Duties may be delegated to an individual supervised by the PI.

3. Laser Operator (LO) Responsibilities:

- Complete the applicable online Laser Safety course before operating a Class 3b or 4 laser and again at the interval specified in this policy manual.
- Use lasers safely.
- Comply with established policy, SOPs and other procedural requirements.
- Promptly report to the PI any malfunctions, problems, accidents, or injuries, which may have an impact on safety.
- Ensure that all lab visitors are properly informed of and protected from all potential hazards.

B. Laser Classification

All lasers and laser systems in the U.S. are categorized into one of several hazard classes. Corresponding labels affixed to the laser or laser system positively identify the class. These laser classifications are detailed in ANSI Z136.1 and the Federal Laser Products Performance Standard, 21 CFR 1040.10 and 1040.11. The manufacturer provides the classification for most lasers. For custom-built and modified lasers, the LSO can assist with classification.

1. Class 1

- Do not emit harmful levels of radiation during normal operation.
- Also includes higher class lasers completely enclosed and interlocked to prevent beam access, allowing a Class 1 laser system designation. Any time the higher-class laser is accessible (e.g. during alignment or servicing), the higher laser class controls must be observed.
- Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.
- Examples include: laser printers, CDROM players/recorders.

2. Class 2

- Emit accessible laser light in the visible wavelength region.
- Capable of creating eye damage through chronic exposure.
- In general, the human eye will blink within 0.25 seconds when exposed to Class 2 laser light; this blink reflex provides adequate protection.
- Can be used without restriction in the manner intended by the manufacturer and without special operator training or qualification.
- Examples include: some laser pointers, alignment tools.

3. Class 3a

- Normally not hazardous when viewed momentarily with the unaided eye but may pose severe eye hazards when viewed through collecting optics (e.g., microscopes and binoculars).
- Same controls as Class 1 and Class 2 lasers for normal operations; if viewed through optical instruments (e.g., binoculars, telescopes, or microscopes), contact the LSO for a hazard review.
- Examples include: laser levels, some laser pointers.

4. Class 3b

- Will cause injury upon direct viewing of the beam and specular reflections.
- Must implement specific control measures covered in this policy.
- Examples include: Flow cytometers, laser confocal scanning microscopes, and Raman spectrometers. Low-power lasers--including visible to near-infrared diode lasers, nitrogen and dye lasers, and helium-neon lasers--used for diagnostics, characterization (and control) of aerosols and sprays relevant to environmental control and fuel injection optimization.

5. Class 4

- Pose eye hazards, skin hazards, and fire hazards. Viewing the beam or specular reflections or exposure to diffuse reflections can cause eye and skin injuries.
- All control measures explained in this document must be implemented.
- Examples include: Raman spectrometers and high powered lasers used for advanced materials-processing methods. Capabilities include cladding, cutting, drilling, surface modification (heat treating, glazing, surface alloying), welding, process monitoring, and laser thermal simulation studies.

C. Embedded Lasers

Lasers are often embedded in laser products or systems with a lower hazard class. When the laser system is used as intended, the controls for the system's class apply. When the system is opened (e.g., for service or alignment) and the embedded laser beam is accessible, a temporary control area must be established based on the classification of the embedded laser. The user and LSO must determine adequate controls. Confirmation of a system classification is the responsibility of the LSO and therefore necessitates registering the system. An abbreviated SOPs may be required, as in the case of such commercially available enclosed laser systems as a laser scanning confocal microscope.

D. Laser Acquisition, Transfer, and Disposal

Notify the LSO of any decision to purchase, fabricate, or otherwise acquire a Class 3b or Class 4 laser. The LSO will review with the user the hazards of the proposed operation and make recommendations regarding the specific safety requirements that pertain to the proposed use, including requirements for SOPs, laser control areas, training, and personnel protective equipment. Also notify the LSO of any class 3b or 4 laser or laser system relocated, transferred to another PI or institution, or sent offsite as surplus equipment.

E. Laser Hazard Control Measures

1. Controls for Class 1, 2, and 3a Lasers

Class 1, 2, and 3a laser beams may not be intentionally directed at the head or face of another person.
Class 3a laser beams must not be viewed with collecting optics (e.g. microscopes) unless the optical system is specifically designed and constructed to prevent eye exposure exceeding the applicable MPE.
Otherwise, no other specific laser safety requirements apply to Class 1, 2, and 3a lasers.

2. Controls for Class 3b and Class 4 Lasers

Class 3b and Class 4 lasers may be operated only in designated laser controlled areas. The purpose of laser controlled areas is to confine laser hazards to well-defined spaces that are under the control of the laser operator, thereby preventing injury to those visiting and working near the controlled area. All personnel authorized to enter a Class 3b or Class 4 laser controlled area shall be appropriately trained, and must follow all applicable administrative and operational controls.

a. Posting

The area must be posted with appropriate warning signs that indicate the nature of the hazard. The wording on the signs will be specified by the LSO and conform to the ANSI Z136.1 guidelines. Such signs shall be posted at all entrances to the laser control area during the time a procedure utilizing the active beam is in progress.

b. Authorization

Only individuals who have been authorized by the PI may operate the laser. Individuals may be authorized upon completing the applicable online laser safety training. The PI may stipulate additional authorization requirements.

c. Beam Stop

All laser beams, other than those applied to tissue for surgical or therapeutic purposes, must be terminated at the end of their useful paths by a material that is non-reflective and (for class 4 lasers) fire resistant.

d. Eye Protection

Lasers should be mounted so that the beam path is not at eye level for standing or seated individuals. Laser protective eyewear of adequate optical density and threshold limit for the beam(s) under manipulation must be provided and worn whenever laser exposure could exceed the MPE. Procedures and practices must ensure that optical systems and power levels are not adjusted upstream during critical open beam operations, such as beam alignment. The need for laser eye protection must be balanced by the need for adequate visible light transmission. It is the responsibility of the PI to obtain appropriate laser protective eyewear. For assistance in selecting laser eye protection, contact the LSO at ehrs@drexel.edu. The LSO can assist the user in determining the proper parameters of such eyewear, and can provide contact numbers for vendors. Laser eye protection should be inspected periodically to ensure that it is in good condition.

e. Light Containment

Laser light levels in excess of the MPE must not pass the boundaries of the control area. All windows, doorways, open portals, and other openings through which light might escape from a laser control area must be covered or shielded in such a manner as to preclude the transmission of laser light. Special rules apply for outdoor use and laser control areas that do not provide complete containment. Contact the LSO for details. Where feasible, the laser user is required to keep all laser beams within the operating field, on the optical table or within the experimental envelope at all times. To maintain this control, it is essential to be aware of all beams, including stray beams and/or reflections, and to terminate them with beam stops at the

end of their useful paths. When a beam traverses to other tables or across aisles, the beam must be enclosed or the access to the aisle must be blocked to prevent personnel from exposure to the beam.

f. Key Switches

For those laser systems equipped with a key switch to prevent unauthorized use, the key must not be left in the switch when the laser system is unattended.

3. Additional Controls for Class 4 Lasers

Only appropriately trained personnel may enter a Class 4 laser controlled area during the time a procedure utilizing the active beam is in progress. All personnel within the controlled area must be provided with appropriate protective equipment and are required to follow all applicable administrative controls. Class 4 laser controlled areas must meet all of the requirements that apply to Class 3b controlled areas and also the following requirements:

a. Laser Activation Warning Systems and Entry Controls

Procedural area or entryway controls must be in place to prevent inadvertent entry into a laser controlled area, or inadvertent exposure to the active laser beam. These measures must include:

- A visible warning sign must be at the entrance to the controlled area to indicate when the laser is energized and operating. The visible sign must be in accordance with the ANZI 136.1. The sign must light up when activated by a light switch in the laboratory.
- Provision for authorized personnel with proper training to obtain proper laser protective eyewear prior to entering the room.
- Doors or blocking curtains/barriers that attenuate the laser beam to below the MPE at the entranceway.
- A formal hazard evaluation by the LSO may require more rigorous entryway controls to be put into place, depending upon the level of the hazard. These may include door interlocks or other entryway safety controls.

4. Special Requirements for Invisible Laser Beams

Since infrared (IR) and ultraviolet (UV) laser beams are not within the boundaries of normal human vision, they possess a higher hazard potential than visible light lasers. Because of the invisible nature of the optical radiation, the use of laser eyewear that will protect against worst-case exposures is required at all times.

Infrared (IR) laser beams (> 760 nm) must be terminated by a highly absorbent, non-specular backstop. Note that many surfaces that appear dull are excellent IR reflectors and would not be suitable for this purpose. Class 4 IR laser beam terminators must be made of a fire-retardant material, or of a material which has been treated to be fire-retardant.

Ultraviolet (UV) radiation from UV lasers causes photochemical reaction in the eyes and the skin, as well as in materials that are found in laboratories. The latter may cause hazardous by-products such as ozone and skin sensitizing agents. The direct beam and scattered radiation should be shielded to the practical maximum extent to avoid such problems. The use of long-sleeved coats, gloves, and face protectors is recommended. Note that new clothing may only have a sun protection factor (SPF) of 5, whereas clothing that has been washed multiple times may have a SPF rating of 30 or better because of the optical whiteners in laundry detergent. Some medications, including tetracycline, doxycycline, tricyclic antidepressants, and

methotrexate, can increase a person's risk to UV radiation. Contact the LSO at ehrs@drexel.edu for more information about this subject.

5. Substitution of Alternate Control Measures

Upon documented review by the LSO, the engineering control measures recommended by ANSI Z136.1 for Class 3b and Class 4 lasers or laser systems may be replaced by administrative or other alternate engineering controls that provide equivalent protection. Alternative controls must be approved by the LSO prior to implementing.

6. Temporary Laser Controlled Areas

Temporary laser controlled areas can be created for the servicing and alignment of embedded lasers, enclosed lasers, and in special cases where permanent laser control areas cannot be provided. They are subject to the normal SOP approval process.

F. Laser Related Non-Beam Hazards & Control Measures

While beam hazards are the most prominent laser hazards, other hazards pose equal or possibly greater risk of injury or death. These hazards must be reviewed by the LSO and addressed by the PI in the SOP for the laser operation where applicable.

1. Electrical Hazards

Some lasers use high-voltage power supplies, large capacitors, or capacitor banks that present a lethal shock hazard. Additional hazards of electrical equipment include resistive heating and ignition source. The electrical safety controls include:

- The Occupational Safety and Health Administration (OSHA) [29 Code of Federal Regulations (CFR) Title 29 Section 1910 Subpart S] requires additional controls and training for work on live circuits operating at more than 50 volts. Note also that capacitors maintain a lethal charge even in deenergized and unplugged equipment. Use extreme caution if servicing laser power supplies.
- Review and comply with the Electrical Safety in this manual.
- Check the condition of electrical insulation and ensure that electrical terminals are covered. Repair or replace damaged equipment.
- Ensure good equipment grounding (i.e., chassis/frame resistance to ground limited to a few ohms).
- Follow good wiring practices (e.g., use ground fault circuit interrupter [GFCI] outlets, no wires on the floor, no overloaded circuits, etc.).
- Use equipment only for its intended/designed purpose.
- Keep equipment "power up" warning lights clearly visible.

2. Laser Dyes

Dyes used as the optically active medium in some lasers are often toxic and/or carcinogenic chemicals dissolved in flammable solvents. This creates the potential for personnel exposures above permissible limits, as well as fires and chemical spills. For each dye used, the PI must have the Safety Data Sheet (SDS) available for staff review and in general ensure compliance with applicable Drexel policies governing hazardous chemical use and disposal.

3. Compressed Gases and Cryogenics

Hazardous gases may be used in laser applications, i.e., excimer lasers (fluorine, hydrogen chloride). Cryogenic fluids are used in cooling systems of some lasers. The SOP must contain references for the safe handling of compressed gases.

Gases that pose a toxic inhalation hazard must be stored ventilated gas cabinets. The cabinets must be equipped with purge and shutoff mechanisms. In addition, the laboratory must have gas detection system to monitor for leaks. Contact the LSO at ehrs@drexel.edu for assistance regarding compressed gases.

4. Laser Generated Air Contaminants

Air contaminants may be generated when Class 3b and Class 4 laser beams interact with matter. When target irradiance reaches a threshold of about 107 W/cm2, target materials including plastics, composites, metals, and tissues may liberate toxic and noxious airborne contaminants. Generally, the PI must ensure that any laser operation that creates visible smoke or plume has adequate local exhaust ventilation in place and include this provision in the SOP. Respiratory protection is not an acceptable alternative to local exhaust ventilation. If, in addition to local exhaust ventilation, respiratory protection is required or worn voluntarily, contact the LSO at ehrs@drexel.edu for assistance.

5. Plasma Radiation

Interactions between very high power (~1012 W/cm^2) laser beams and target materials may produce a plasma, which in turn generates "blue light" and UV emissions that pose an eye and skin hazard. Similarly, targets heated to very high temperatures (e.g. in laser welding and cutting) emit an intense light. The PI must ensure adequate control measures are in place and addressed in the SOP for such operations.

6. UV and Visible Radiation

Laser discharge tubes and pump lamps may generate sufficient UV and visible radiation to pose an eye and skin hazard. To address this issue, maintain the integrity of the laser housing and avoid operating any laser with the housing removed.

7. Explosion Hazards

High-pressure arc lamps, filament lamps, and capacitors may explode if they fail during operation. Keep these components enclosed in the laser housing, which will withstand the maximum explosive forces that may be produced. Laser targets and some optical components also may shatter if heat cannot be dissipated quickly enough. Ensure adequate mechanical shielding when exposing brittle materials to high intensity lasers.

8. Ionizing Radiation (X-rays)

X-rays could be produced from two main sources: high voltage vacuum tubes of laser power supplies such as rectifiers and thyratrons and electric discharge lasers. Any power supplies that require more than 15 kilovolts may produce enough x-rays to be a health concern. Consult the Radiation Safety Office for review and control of such hazards.

G. Laser Safety Training

- All employees who use Class 3b or Class 4 lasers must complete the appropriate online laser safety course.
- Visitors requesting to use or observe Class 3b or Class 4 lasers must complete the required online safety courses prior to entering any university laboratory. The visitor may only use lasers under the presence and guidance of a PI (or designee) or laser operator.
- The PI must provide site specific training to all laboratory members concerning the laser system. The training must be documented and uploaded to the Documents section in BioRAFT.
- Laser users are also responsible for knowing the safety requirements that apply to their specific laser or laser system and for knowing the contents of the applicable SOP.
- Laser users must retake the laser safety course at an interval not to exceed one year.

H. Medical Surveillance

The LSO may require laboratory personnel working with certain Class 3b and/or Class 4 lasers to obtain a pre-employment medical examination specific to laser use. EHRS will evaluate the need for such surveillance on a case by case basis. Employees must contact EHRS at ehrs@drexel.edu to schedule an appointment with Occupational Health Services if deemed necessary. Students must schedule an appoint with their primary care physician or ophthalmologist using their own insurance if the examination is required.

Following any suspected laser injury, employees must report the incident to the PI or laboratory supervisor and seek medical attention at Occupational Health Services if they believe that they may have been injured. Students must seek medical attention at Student Health or any emergency room using their own insurance.

I. Laser Accidents

- Laser users must report all laser accidents, no matter how minimal, to the PI responsible for the laser system involved. The PI must report any accidents causing injury or property damage to the LSO at 215-895-5919 or via email at ehrs@drexel.edu. If immediate assistance from the LSO is required, call 215-895-2222, indicate to the operator that a laser accident has occurred, and direct them to notify EHRS. All life-threatening injuries call 911.
- Employees must report must seek medical attention at Occupational Health Services if they believe that they may have been injured. Students must seek medical attention at Student Health or any emergency room using their own insurance. If an incident occurs outside the operating hours of OHS, employees must seek medical attention at the closest emergency room.
- Notify the supervisor of the injured individual(s) to ensure action is taken to prevent any further injury to other personnel. The supervisor shall notify the LSO within 24 hours after the initial reporting of the incident. The LSO will inform Radiation Safety and other relevant personnel of actions being taken or required as part of the medical investigation.

J. Standard Operating Procedure (SOP)

An approved written SOP must be provided by the PI for all Class 3b and Class 4 laser systems. This SOP should cover laser operations (i.e., description of activities, hazard identification and mitigation, routine alignment procedures) and other relevant hazards in the laser environment. A general laser SOP template is available by contacting the LSO at ehrs@drexel.edu The use of the template is highly recommended. The template provides a guide for the laser user in identifying the characteristics of the laser operation and

collateral hazards, and in formulating set-up and alignment procedures. Contact the LSO at safeheal@drexel.edu for assistance in developing control measures and completing the SOP.

In the case of enclosed systems (e.g., laser scanning confocal microscopy) an abbreviated SOP can be applied after an experimental review by the LSO, who will then determine the SOP sections required. This abbreviated SOP follows the standard SOP approval process.

All SOPs need to be reviewed annually by personnel working with lasers to ensure the accuracy of the procedure(s). If no new hazards have been added to the system, the users can perform the review without notifying the LSO. If new hazards (use of a sub-nanosecond laser system, for example) have been added to the experiment, a review by the LSO is necessary to assure all applicable safeguards have been satisfied.

A specified time period, agreed upon by the PI and the LSO, will be established between the setting up of the laser equipment and the submission of the SOP draft document. With the assistance of the user the LSO will develop a set of documented conditions for the laser user to operate the laser during the interim or, alternatively, the laser will be operated only according to the manufacturer's written instructions. These conditions will be posted in the laser environment and sent to the appropriate departmental lab safety liaison.

Any temporary modification, alignment procedure, repair, etc. which would result in a change in laser classification from Class 1 to Class 3b or 4 will follow manufacturer's instructions or be approved by the LSO in advance.

XVI. Hazardous Material Emergency Response

The Hazardous Materials Emergency Response plan is designed to minimize hazards to human health and the resulting environment from any unplanned release of hazardous materials. This plan outlines the emergency procedures that shall be followed by personnel if hazardous materials are released. EHRS has designed the Hazardous Materials Emergency Response plan in compliance with all local, state, and federal regulations.

A. Training

EHRS will provide training to all university employees who handle hazardous materials in laboratories. Each employee shall receive training on proper handling of chemicals and emergency response procedures.

Initial training must be completed during the first month of employment and annually thereafter. Emergency procedure training will be conducted as part of the annual laboratory safety training. Additional training sessions can be arranged by email EHRS at ehrs@drexel.edu.

The Department of Environmental Health and Radiation Safety shall document all emergency response training. Training records will be kept for at least three years from the date the employee last worked at the university.

B. Hazardous Material Spill Identification

EHRS separates hazardous material spills into two categories: Major or Minor.

1. Major Spills

EHRS characterizes major spills as any one of the following:

- Chemical spills greater than 500 milliliters or grams.
- Chemical spills involving any amount of acutely hazardous materials.
- Blood spills greater than 500 milliliters.
- Any amount of Select Agents.
- Any amount of hazardous gases.
- Any amount of mercury and mercury compounds
- Radioactive materials released where the nature of the potential hazard cannot be ascertained, someone is contaminated, the release is in unrestricted areas, there is airborne radioactive materials generated, there are injuries that might involve the material, uptake potential is high, and evacuation of the room or building is necessary.

2. Minor Spills

EHRS characterizes a minor spill as a small spill that is less than 500 milliliters or grams of non-acutely hazardous materials.

An incident involving radioactive material can be considered minor if the following conditions are met:

- The nature and potential hazards are known
- There is no contamination of personnel
- One or two people can clean up the incident in about an hour
- There is no release of radioactive material into unrestricted areas
- There is no airborne radioactive material
- There are no injuries (e.g., lacerations from broken glass) except where radioactive material is not involved and medical attention is not required
- There is no potential uptake of radioactive material

All minor spills must be reported to EHRS the day of the incident. The incident can be reported to EHRS by email at ehrs@drexel.edu.

C. Hazardous Material Spill Procedures for Minor Spills

Laboratory personnel are responsible for the containment and clean-up of all **minor** spills.

1. Minor Chemical Spill

- Notify persons in the immediate area that a minor spill has occurred.
- Immediately implement personal decontamination procedures if injured or contaminated with a hazardous substance prior to reporting spill. Utilize the eyewash or safety shower to remove contamination.
- Notify your supervisor a spill has occurred.
- Prior to initiating the clean-up review the safety data sheet for the spilled material to determine the required personal protection equipment and best clean-up method.

- Proper personal protection equipment must be worn during the clean-up of all **minor** spills. Contact EHRS for assistance if appropriate PPE is not available.
- Use the spill kits to clean-up the spill. The kits contain splash goggles, heavy duty gloves, chemical apron, neutralizing agents, waste bags, and absorbent pads.
- All non-disposable personal protective equipment shall be decontaminated and stored.
- All disposable personal protective equipment and clean up materials shall be disposed of as hazardous waste.

2. Minor Spill of Blood or Other Potentially Infectious Materials (OPIM).

- Notify persons in the immediate area that a minor spill has occurred.
- Immediately implement personal decontamination procedures if injured or contaminated with a hazardous substance prior to reporting spill. Utilize the eyewash or safety shower to remove contamination.
- Notify your supervisor a spill has occurred.
- All spills must be immediately contained and cleaned by appropriately trained personnel. Utilize Universal Precautions when cleaning blood or OPIM.
- Personnel must wear hand, eye and skin personal protection during the cleanup. Contact EHRS at 215-895-5919 or via email at ehrs@drexel.edu for assistance if appropriate PPE is not available.
- Sharps are NOT to be picked up directly with the hands and shall be cleaned up using mechanical means. Dispose all sharps in an approved sharps container. Spray mist disinfectant over entire spill area. Do not pour or spray direct stream at the spill to prevent splashing and aerosolization of the material. Allow the disinfectant to remain in contact with contaminated area for the product manufacturer's recommended contact time or in the case of 10% bleach allow at least ten minutes.
- Wipe/sweep up using appropriate absorbent pads or towels. Place soiled absorbent in infectious waste bag.
- Repeat applying disinfectant over the entire area. Allow surface to air dry.
- Remove personal protection equipment. Dispose of gloves in infectious waste bag. Disinfect all non-disposable personal protection equipment and cleanup tools.
- Wash hands and arms.
- Contact EHS for disposal of infectious waste.

3. Minor Radioactive Spill

- **Notify** all other persons in the room or area that a spill has occurred.
- **Prevent spread of contamination** by covering the spill with absorbent paper.
- **Decontaminate** the area. Using paper towels or absorbent pads, clean towards the center of the spill. Place all waste into plastic bag and dispose as radioactive waste. Disposable gloves, lab coat, and if appropriate, shoe covers should be worn. Cleansing agents may be used after initial decontamination attempt.
- **Survey** the area and all contaminated and potentially contaminated individuals with a G-M survey meter. Survey for removable contamination using wipe samples.
- **Report** the incident to the Radiation Safety Office at 215-895-5919 or via email at ehrs@drexel.edu.

D. Hazardous Material Spill Procedures for Major Spills

All major spills will be cleaned up by EHRS or a qualified contractor. An incident involving radioactive materials is considered major when the following conditions are met:

- The nature or potential hazard cannot be ascertained.
- Personal contamination (skin or clothing; contamination of personal protective equipment, e.g., lab coats is not personal contamination).
- The cleanup will take more than two people or more than an hour to perform.
- There is a release of radioactive material into unrestricted areas.
- Airborne radioactive material is generated.
- Injuries which might involve radioactive material (e.g., laceration from contaminated glass)
- Injuries which require medical attention.
- There exists the potential for an uptake of radioactive material.
- Fire or explosion.
- Evacuation of the room or building is necessary.

For more information on the university radiation safety program, consult the university's Radiation Safety Manual.

1. Major Chemical or Blood Spill

- Notify persons in the immediate area that a spill has occurred.
- Avoid breathing vapors, mists, or dust of the spilled material.
- If possible turn off all ignition sources, turn on chemical fume hood exhaust and open sash if spill is not in hood.
- Immediately implement personal decontamination procedures if contaminated with a hazardous substance prior to reporting spill.
- Evacuate room and close the door.
- Contact the Public Safety 24-hour Call Center at 215-895-2222.
- Provide the following information to the Dispatcher:
  - Name and call back number.
  - The location of the spill (building and room number).
  - Type of material spilled.
  - The amount of material spilled.
- Remain on or near the telephone until you have received instructions from the Public Safety or EHS.

2. Major Radioactive Material Spill

- **Clear the area**: notify all persons not involved with or near the spill to vacate the room.
- **Prevent spread of contamination:** cover the spill with absorbent paper. Do NOT attempt to clean it up. Assemble all potentially contaminated personnel near the room entrance.
- **Close the room**: prevent entry into the room.
- **Call for help**: Immediately contact Radiation Safety.
- **Decontaminate personnel**: Survey personnel for contamination. Contaminated clothing should be removed and stored for evaluation by Radiation Safety. Contaminated skin should be flushed thoroughly with lukewarm water and then washed with mild soap and lukewarm water.

E. Personal Decontamination Procedures

Please be advised that these procedures are general decontamination procedures. These procedures might not be appropriate for certain types of hazardous materials. In effort to ensure proper decontamination

consult the Safety Data Sheet prior to conducting any experiments. Implement **immediately if contaminated with a hazardous substance** prior to cleaning up or reporting spill:

For spills contacting the of skin, follow these procedures:

- Immediately flush with flowing water for no less than 15 minutes (i.e. sink or safety shower).
- If there is no visible burn, wash with warm water and soap, removing any jewelry to facilitate clearing of any residual material.
- Check the material safety data sheet to see if any delayed effects should be expected. If the SDS is not available contact the EHRS immediately at 215-895-5919 or 215-778-4278.
- Seek medical attention for even minor chemical burns.
- Do not use creams, lotions, or salves.

For spills on clothing, follow these procedures:

- Do not attempt to wipe the clothes.
- Quickly activate the safety shower and remove all contaminated clothing, shoes, and jewelry.
- Seconds count, so do not waste time because of modesty
- Take care not to spread the chemical on the skin or, especially, in the eyes.
- Use caution when removing pullover shirts or sweaters to prevent contamination of the eyes; it may be better to cut the garments off.
- Immediately flood the affected body area with warm water for no less than 15 minutes. Resume if pain returns.
- Get medical attention as soon as possible.
- Discard contaminated clothes as hazardous waste or have them laundered separately from other clothing.

For splashes into the eye, take these steps:

- Using the eyewash immediately flush for at least 15 minutes.
- Hold the eyelids away from the eyeball and move the eye up and down and sideways to wash thoroughly behind the eyelids.
- Get medical attention immediately. Follow first aid by prompt treatment by a member of a medical staff or an ophthalmologist who is acquainted with chemical injuries.