General and Laboratory Safety Handbook

An Overview of Safe Operating Procedures

Contact:
Dr. Urmila Basu
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Our commitment to Safety

The Faculty of ALES strives to maintain a safe environment and to encourage safe practices through the Safety Program. It is also the responsibility of the supervisors, individuals and 'work groups' to be familiar with different aspects of safety and to employ that knowledge every day.

The ALES Safety Handbook outlines regulations, training requirements, general safety procedures, laboratory chemical safety and biosafety that must be followed by all staff conducting laboratory research. However, these information sources can only supplement the necessary job-related training arranged by supervisors, i.e., task- and site-specific safety information, and any other required training. For additional safety information, researchers can refer to https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/training/index.html. If you have questions or concerns, you are encouraged to consult with your supervisor or other staff.

Emergency Numbers, Contacts and Location of Resources

- Medical Emergency/Ambulance: 911
- Smoke or Fire: 911
- Police: 911
- Protective Services (for suspicious person/ unusual activity): 780-492-5050
- Building Emergency (water, flood, power outage or heat emergency): 780-492-4833 https://request.facilities.ualberta.ca/

Contacts in ALES

Victoria Sandberg, Faculty Safety Advisor, alessafe@ualberta.ca
Dr. Urmila Basu, ALES Research Labs Manager, ubasu@ualberta.ca; For inquiries related to all core labs and equipment, genomics technologies, and safety
Dr. Kelvin Lien, Occupational Health and Safety Advisor, klien@ualberta.ca, For Chemical and lab safety information
Heather Vandertol-Vanier, Biosafety Technologist, hav2@ualberta.ca; For Biosafety information
Allie Dunlop, Department Teaching; adunlop@ualberta.ca: For RenR lab safety information
Stephanie Ramage, HNRU coordinator, stephanie.ramage@ualberta.ca, For HNRU safety informatiom

Door Signage

All labs have an 'Environmental Health and Safety Laboratory Hazard Sign' indicating hazards present in that laboratory and the emergency contact information. You can also contact your Unit Manager or supervisor for all inquiries.

Building ('infrastructure') problems

All students and staff must be familiar with the Emergency Response Plan and Fire Evacuation Plan of their lab (developed by their supervisor or the facility manager).
In the event of serious water or steam leaks, suspected natural gas leaks, unusual odors (not easily traceable to lab work), heating or humidity problems, malfunctioning fans or fume hoods, plugged drains, burnt-out lights, etc.- contact https://request.facilities.ualberta.ca/

When the Fire Alarm Sounds

Stop what you are doing and leave. Do not assume it is a drill! During working hours, Emergency Wardens check that everyone evacuates. Fire extinguishers are located in most laboratories and in hallway "fire cabinets".

Fire Alarm Pull Stations

- First Floor: hallway west of east washrooms; opposite main elevator; outside west washrooms; inside southwest entrance; outside AF 1-12; across from AF 1-63; loading dock; by freight elevator.
- Second Floor: hallway south of AF 2-58; west of east washrooms; east of central doors in main hallway; outside AF 2-14 to the west; outside west washrooms; by freight elevator.
- Third Floor: by southwest stairway; east of central doors in main hallway; inside east hallway doors; inside west hallway doors; across from main elevator; by freight elevator.
- Fourth Floor: outside west washrooms; across from main elevator; by west staircase doors; east of central doors in main hallway; hallway across from AF 4-73; west end of north hallway; across from AF 4-31; by freight elevator.
- Fifth Floor: just inside south doorway of AF 5-17; across from main elevator; by west staircase doors; by freight elevator.
- For all labs and offices in SAB, ESB, GSB, and HEB, ensure you know where the nearest fire alarm pull station is.

Eye wash Stations / "Drench Hoses" (low pressure, high volume, hand-held)

- For all labs, ensure you know where the nearest eye wash station and safety shower is located. This information should be covered in lab-specific safety training for new staff and students.
- Ag/For- Many laboratories have "drench hoses". Emergency Showers ("Overhead") are located in east hallway of 2nd and 3rd floors, 1-20E, 1-20F, and 3-36.
- Most labs in SAB, ESB, and HEB have their own eye wash stations and safety showers in the labs, or in the hallways outside the lab. If an eye wash station is not readily available in or near your lab, eye wash bottles can be purchased and stored in the lab. Inspect them periodically to ensure the solution is not expired, and replace them if used.

Safety Data Sheets (SDSs)

The principal means to access currents SDSs is through an on-line computer search (https://www.sigmaaldrich.com/safety-center.html).

First Aid Kits and Small Chemical Spill Clean-Up Kits

- Ag/For- Major first aid kits are in AF 4-35 (NE corner), AF 2-58 (just inside the door), outside AF 3-51 (on a table), and in the central area of AF 1-20. Basic supplies are in many laboratories.
- Spill "Kits" are in AF 1-20, AF 2-58, on a cart outside AF 3-49, and in AF 4-35 and AF 5-17D. Bottles of clean-up mix are in most laboratories. A metallic mercury clean-up "kit" is in AF 2-58.
- Labs in SAB, ESB, and HEB supply their own first aid kits and chemical spill kits. Refer to your lab's safety documentation for locations and more information.

Telephones

Most offices and laboratories have telephones. On-campus numbers generally begin with “2” or “8” followed by four digits. Off-campus local numbers are reached by dialing “9” followed by the 10-digit number.

Safety Rules and Regulations

Occupational Health and Safety (OHS) Responsibility

The Faculty of ALES is committed to providing a safe work environment for all of its staff, students and volunteers. The standards for health and safety are defined in the Alberta Occupational Health and Safety (OHS) Act, Regulation and Code. This legislation outlines supervisor and worker rights, duties and obligations and provides the requirements they must meet to protect their own health and safety as well as that of others associated with the workplace. In Alberta, graduate students, postdoctoral fellows, and research associates are considered workers.

The General Duty Clause

Alberta legislation dictates that workplace health and safety is a shared responsibility. The "General Duty Clause" holds employers responsible for preventing occupational illness and injuries by obligating them to do everything 'reasonably practicable' to:

> protect the health and safety of employees and visitors to their work site, and
> ensure that their employees are aware of their duties and responsibilities under the OHS Act, Regulations, and Code. OHS Act, Section 2(1)

Workers also have duties under the legislation. They must:

> work in a safe manner, taking reasonable care to protect their health and safety and that of other workers, and
> co-operate with their employer in the health and safety measures that have been implemented. OHS Act, Section 2(2)

Hazard Assessment, Elimination and Control

A hazard is any situation, condition, or thing that may be dangerous to the safety or health of workers. OHS legislation (OHS Code, Part 2) recognizes that an effective means of protecting worker health and safety is to identify hazards in the workplace, then to either eliminate them completely or put in place effective measures by which they can be controlled. From a laboratory perspective, important potential sources of hazards include, but are not limited to:

- *Physical workspace* – includes cleanliness and other conditions of the workplace that could lead to injuries such as slips, trips, falls etc.
- *Equipment* - anything used to equip workers at a worksite including tools, supplies, and machinery.
- *Controlled products* - any product, material or substances included in one or more of the six WHMIS classes (includes nearly all chemicals).
- *Hazardous Substances* - substances that, because of their properties, application, or presence, create or could create a danger, including a chemical or biological hazard, to the health and safety of a worker exposed to it. Exposure to hazardous substances must be kept as low as reasonably practicable/achievable when there are no established occupational exposure limits OHS Code part 4

Jobs and tasks (work processes; e.g., analytical procedures) must be assessed to identify existing and potential hazards prior to beginning the work. A hazard assessment must be repeated when a new work process (involving the use of new materials, chemicals, equipment, etc.) is introduced or an existing work process is changed. Identified hazards must either be eliminated or, if elimination is not reasonably practicable, measures must be implemented in a hierarchical fashion to control them:

- Engineering controls – physical controls directed at the source, or as close to the source, of hazards as possible (isolation, barriers, guards, etc.).
  Fume hoods are an important means of controlling airborne hazards in laboratories.
- Administrative controls – rules, policies, safe work practices/procedures, training etc. that outline how workers are to safely work with or manage the hazard.
  Standard/Safe Operating Procedures (SOPs) serve many of these purposes.
- Personal Protective Equipment (PPE) - eye, hand, head, hearing, and respiratory protection. Like administrative controls, PPE reduce the likelihood and severity of injury, but do not eliminate the hazard.
- Combination of Control Methods - all reasonable and practicable measures must be taken to control the hazard, even if it requires more than a single measure.

See Appendix 2 for an example of a hazard assessment. Existing hazard assessments for labs may be in this format and stored with each lab's safety documents. They can be retained in this format when updating them. New hazard assessments should be generated using the online hazard assessment tool from HSE: https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/self-help/hazard-assessment-web-application.html.

University of Alberta Health and Safety Responsibilities Procedure (see UAPPOL)

- The University defines a supervisor as a person who has control over assigned work and authority over the persons conducting the work OR a person who has been delegated responsibility for instructing, directing or controlling staff or students working or studying at the University of Alberta. This broad definition encompasses anyone who directs the work of others, and includes PIs, managers, supervisors, TAs, graduate students who direct undergrads or technicians, and others. In meeting the requirements of Alberta OHS legislation, the University has ascribed the following responsibilities to supervisors (remember that workers and students are required to cooperate with every aspect of the Supervisor's program):
- Supervisors, in cooperation with staff, identify hazards and implement appropriate measures to eliminate or control the hazards. A written record of the hazard assessment is required.
- It is the responsibility of the supervisor to develop specific health and safety guidelines and safe work procedures for their area of supervision through the hazard assessments.
- Supervisors must ensure all staff have the required skills and are competent to perform the work safely using the appropriate safe work procedures. Working within this framework, supervisors ensure adequate job/task training and health and safety training.
- All supervisors must complete the Supervisory Training Course through HSE.

Refusal of Unsafe Work

- The right of the employer to direct work is balanced by the requirement of employees to refuse unsafe work that presents an imminent danger to the health or safety of themselves or others in the workplace.
- No worker shall carry out work or operate any tool, appliance or equipment if on reasonable and probable grounds they believe that there exists an imminent danger to the health and safety of themselves or others around them. OHS Act Section 35
- Dangerous conditions must be reported to a supervisor so that corrective actions can be taken.

Safety Information Seminar

All new staff and students are encouraged to attend the Safety Information Seminar offered by Dr. Urmila Basu in the beginning of fall, winter or spring/summer terms. Subsequent to the general Laboratory Safety training sessions, researchers may need to take specialized safety training depending on the nature of their work. In addition, all laboratory personnel must complete the Unit-specific, Lab-Specific and Task- specific training, provided by the Principal Investigator (PI) or their designee.

Safety of Facilities

- All new students and staff can contact Holly Horvath (780-492-2131, AF 4-10) for keys to the lab and office areas in Agriculture/Forestry Building.
- New staff and students can contact Christie Nohos for keys to labs and office areas in SAB, ESB, GSB, HEB (780-492-4413, GSB 751).
- Whenever there is no one in a lab or other restricted area, doors should be closed and locked (if you are not sure if there is anyone in the area, lock the door).
- Labs with fume hoods should keep doors closed at all times to ensure negative pressure conditions for proper fume hood operation.

First Aid

First Aid Supplies

Most work areas have at least basic first aid supplies. In the Ag/For Centre “major” first aid kit locations are: AF 1-21, AF 2-58, outside Stores (AF 3-51), AF 4-35 and AF 5-17. These major kits have first aid treatment record forms for reporting injury accidents and any treatment rendered.

Automated external defibrillator

An AED is located outside AF 2-21.

Health Centre

Open on regular working days, the Health Centre (2nd floor SUB) is open 8:00 am-5:00 pm. Campus Security personnel (780-492-5050) are first aiders.

Reporting incidents
All incidents, injury or near-miss events involving staff, students, or visitors, while conducting activities in the labs or other research sites on behalf of the U of A, should be reported. These include personal injury, health and safety violation, property damage, hazardous spill and environmental release, stolen or lost property, and near-miss event. Both the employee and the employer report the accident. All incidents must be reported using the HSE online tool at: https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/report-an-incident/index.html.

Incidents resulting in injury – reporting of incidents to WCB
In addition to reporting to HSE and your supervisor, all incidents that result in an injury that requires medical attention must also be reported to WCB. The steps for reporting these incidents are as follows:

1. Fill out the online HSE incident report, both the **employee/student** and **employer/supervisor** components.
2. Fill out the **employee** incident report available on the WCB website. It is suggested to use the fax version.
3. Fill out the **employer/supervisor** incident report available on the WCB website. It is suggested to use the fax version.
4. Send copies of all reports (both HSE reports and both WCB reports) to your departmental office manager and ensure the WCB reports are sent to WCB.

Links and further instructions regarding these incident reporting forms can be found at: https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/report-an-incident/index.html.
Note that all incidents resulting in injury that requires medical attention must be reported to WCB within 72 hours. Failure to do so will result in a $25,000 fine to the department.

Working Alone

- Research or other tasks may require students or staff to be present outside normal hours and should be done under the approval of the supervisor. If you are alone, e.g. in a lab, take precautions to minimize risk, including notifying your supervisor and/or others in the vicinity.
- Hazard assessment is required for all work conducted outside normal hours.
- Keep your office / lab door locked.
- Inform family / room-mates when you intend to leave and when you should arrive home.
- Maintain regularly scheduled contact with your supervisor or a co-worker.
- Be aware of the Lone Worker Program (2-5050) https://www.ualberta.ca/vice-president-finance/protective-services/services/lone-worker.html
- Do not let people in if they don't have a key / One Card.
- Report unusual activity to Protective Services (2-5050).
- Do not carry out potentially hazardous experiments if you are alone.

UofA mobile SafeApp and Safewalk

- Availability of the UofA mobile Safe App, which includes a working alone buddy system and sends important safety alerts and provides instant access to campus safety resources. Can

be downloaded on both the Google Play Store and Apple AppStore.
https://appadvice.com/app/uofa-safe/1275678959

- Safewalk http://www.su.ualberta.ca/services/safewalk/ provides a safe alternative to walking alone at night around the campus.
- It is free of charge and any member of the university community-undergrads, graduate students, staff, and faculty, can avail Safewalk.
- Hours during which Walks are available: 7:00 pm-12:45 am (-10.45 pm Sunday) Winter 6:00 pm-12:45 am (-10.45 pm Sunday). Closed holidays and long weekends.

Training Courses Offered by HSE

The type of research undertaken in the laboratory will determine which courses are required before independently working in the laboratory.

All employees are required to complete this mandatory eLearning as required by the Occupational Health and Safety Act.
Workplace Violence and Harassment Prevention (employee version)
Working Safely at the U of A: A Guide to New OHS Legislation

Additionally, supervisors, anyone who has control over assigned work. Could be a Principal investigator, post doc, research associate or a graduate student, are required to complete the following**:**
Workplace Violence and Harassment Prevention (supervisor version)
Supervisory Health, Safety and Environment Professional Development

Working safely at the U of A: A Guide to New OHS Legislation

All new students and staff must complete the following online training, available from the UofA Health, Safety and Environment before beginning their work in the labs.

- Workplace Hazardous Materials Information System (WHMIS) Safety 2023
- Laboratory and Chemical Safety
- Concepts in Biosafety (if handling biohazards)
- Hazardous Waste Management
- Transport of Dangerous Goods (if required)
- And any other specific safety training required for work

https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/training/index.html

Personal Protective Equipment (PPE)

- Laboratories have several potential hazards which may result from accidental spills and splashes of dangerous chemicals, handling of radioactive material or potential contact with biological agents etc.
- Every U of A lab, under the supervision of the Principal Investigator, must conduct a hazard assessment to identify the hazards for a specific protocol or activity or work environment, and establish the most appropriate PPE protocols so that the individual is protected from exposure to a hazardous material, condition or process.
- All individuals working in U of A labs must know the PPE requirements for the type of work they do and wear the required PPE.
- Each member must sign the PPE checklist document indicating that they are aware of the requirements and the signed PPE checklist must be posted in the lab. https://docs.google.com/document/d/1Ea5PThK93OOaORsg6LObCs6dgt2R2fodIItoqPPvcJ8/edit
- All individuals must wear basic PPE, including lab coats, safety glasses, closed-toe shoes, gloves and long pants.
- Other PPE including safety goggles, splash goggles, hearing protectors or respirators may be required depending on the protocol. Wearing safety glasses vs. safety goggles can be determined through Hazard Assessment and consultation with SDSs.
- Prescription glasses are not considered to be protective eyewear. Personnel may either wear safety glasses over their normal prescription eyeglasses or may order prescription safety glasses.
- Sandals and shorts must not be worn in laboratories or any other hazardous work area.
- Lab coats and gloves are not to be worn in 'public areas' (e.g. SUB, lounges, hallways).
- For teaching labs, the instructor is expected to do hazard assessments for all the protocols, equipment and chemicals/reagents. The signature of each student must be collected on the PPE checklist at the start of the term. The student must be aware of the safety requirements of the particular lab and must comply.
- In some cases, it is possible to change the PPE requirements for a specific activity. e.g., no safety glasses while using the microscope or no gloves while using open flame.
- If you need to deviate from the basic lab PPE, a hazard assessment must be conducted to deal with special situations and provide justification.

- Remove disposable gloves and wash your hands before leaving a laboratory or other work area. Do not contaminate door handles, instrument controls, keyboards, phones, elevator buttons, etc.
- Disposable gloves, if contaminated, must be safely decontaminated before being placed in the garbage, or else they must be collected and disposed of separately as waste.

Working with Radioisotopes

Radioisotopes

- Radioisotopes must be handled only by authorized users in approved areas. Radioisotope labs are marked with appropriate signage. Consult the permit holder before working in a radioisotope area.
- Before working with radioisotopes, it is necessary to take the U of A Radiation Safety Training Course (https://www.ualberta.ca/human-resources-health-safety-environment/environment-and-safety/hazard-management/what-are-my-hazards/radiological/index.html) with online modules and lab session.
- Permit holders (and users) must ensure proper records are kept of radioisotope stocks and usage, and perform regular swipes to verify areas and equipment are not contaminated.

Radioactive Material

- Ensure that all radioactive stocks and second-generation radioactive products are stored in designated freezers and fridges in the radioactive assigned room.
- All records must be retained by the U of A for three years and should either be retained by the faculty member who plans to remain at the University or transferred to the Department should the faculty member leave the U of A.
- A thorough contamination survey using the wipe test technique must be performed on all surfaces of the laboratory where radioactive material is stored or used. This includes floors, handles, bench tops, fume hoods, sinks, equipment, refrigerators and freezers, etc.
- Any radioactive contamination that is found must be removed by using standard decontamination techniques (refer to the Code of Practice for the Protection of Persons from Radioactive Material and Radiation Emitting Devices). The acceptable level of contamination is less than twice the background count rate on a wipe test.

Disposal of Radioactive Waste

- Upon completion of experiments, arrangements must be made for radioisotope waste disposal through Chematix.
- All radioactive waste must be properly packaged for disposal.
- Safe disposal is the responsibility of permit holders and their users.
- Users must specify radioisotopes and total microcuries in packages sent for disposal.
- Update radioactive inventory sheets to reflect disposal of the radioactive material.

Radioisotope Spills

Spill clean-up and subsequent verification are responsibilities of permit holders and users.
Clean up of the spill should only be attempted if it is safe to do so.
If an emergency situation arises, warn others, evacuate the area, phone 2-5555 and give details.

Decertification of the Radioisotope Laboratory Area

After all radioactive material and waste has been disposed of, and the laboratory has been surveyed, decontaminated, and declared free of any radioactive contamination, contact ehs.info@ualberta.ca and request that the laboratory be decertified.

Fire Safety

Responding to and Reporting a Fire

If you discover smoke or other evidence of any fire or emergency:

- Activate the nearest fire alarm box as you leave. Only if safe to do so, shut down critical experiments and turn off associated services before you leave.
- Do not take extra time to collect coats or other personal items.
- Close doors to prevent fire from spreading (for security, doors can be locked, if desired).
- Evacuate via the nearest safe exit (know, in advance, of at least two exits).
- Do not use an elevator. If in smoke or heat, stay low.
- Advise an Emergency Warden of the location and nature of the fire, and, if you know of anyone still in the building, give their location.
- The Control Centre (2-5555) should be advised of the location and nature of the fire.
- The fire should be reported to the Office of Emergency Management (Adam Conway, 780-492-2663).

Should You Try to Control or Put Out a Fire?

- Only if you have activated the fire alarm, and if there is no significant personal risk, and if you have a safe exit, and if the fire has not spread significantly from its origin (e.g. it is relatively easily extinguishable, such as in a waste basket), then you may attempt to extinguish, confine, or control the fire until the Fire Department arrives. The general rule to follow is: if one fire extinguisher is not enough, evacuate the area.
- Know the location and use of fire extinguishers before a fire emergency arises (they are typically near the main exits of labs and in the former fire hose hallway cabinets).

To use an extinguisher, P A S S:
Pull the pin out
Aim low at the base of the fire
Squeeze the trigger
Sweep from side-to-side

Our dry chemical fire extinguishers are rated for type A, B and C fires (i.e. all fires except metal fires; sand can be used to smother metal fires).
Fire extinguishers must be charged, therefore report any fire extinguisher use (Ag/For Ctr: Kelvin Lien; SAB/ESB: Allan Harms; Research Stations: Unit Manager). All fires must be reported to HSE by filing an incident report, even very small fires that are quickly extinguished by lab personnel.

Chemical Safety- Controlling Chemical hazards

Chemical Safety: Ten Basic Rules

1. Know the hazards of chemicals in use. Consult the MSDS/SDS.
2. Label all chemicals containers properly with identity and hazards.
3. Use PPE while handling hazardous chemicals.
4. Work with volatile and hazardous chemicals in a fume hood.
5. Store flammables in flammable storage cabinets.
6. Do not work alone with hazardous chemicals.
7. Maintain clear access to exits, showers and eyewashes.
8. Keep work areas free of clutter and chemicals off the floor.
9. Wash skin promptly if chemical comes in contact with skin.
10. Do not eat, drink or apply cosmetics in the lab.

Working with Chemicals

- Chemical hygiene refers to working 'in a clean manner' with chemicals to reduce the risk of injuries and illnesses from working with and around chemicals. To this end Prudent Practice (NRC, 2011) recommends that we consider four fundamental principles.
    - Plan ahead
    - Do not underestimate hazards or risks
    - Minimize exposure to chemicals
    - Be prepared for accidents

Plan Ahead

- Awareness of the health and safety hazards posed by the various chemicals and procedures used in the workplace, is an important first step in the planning of any experiment.
- Alberta OHS legislation requires that you assess new procedures and processes to identify all hazards prior to beginning any work. You are then required, where elimination of the hazard is not possible, to implement all appropriate measures, including engineering, administrative and personal protective equipment to control the hazards.
- For chemicals: Consider not only the health effects (see Appendix 1), but also physical hazards (flammable, combustible, explosive, oxidizing, pyrophoric, or reactive properties) posed by chemicals.
- A full evaluation of the hazards associated with chemical exposure should consider toxicity of the chemical and the parameters associated with an exposure that would contribute to overall toxic potential. These include, the quantity or concentration of that chemical, route of the exposure, distribution of the exposure over time, time needed to induce an injury or illness in addition to other factors (see Appendix 1).

- Take into consideration any laboratory conditions, that might increase the hazards.
- Consult the appropriate MSDSs/SDSs to be sure that you are familiar with procedures for proper handling, storage, and disposal of the chemicals that you plan to work with.

Never Underestimate the Risks

- All chemicals are hazardous, requiring only the appropriate exposure, under the right conditions, to cause harm.
- Chemicals are capable of causing ill health or adverse effects at the time of exposure or potentially later in your life and in future generations (IUPAC 2007).
- Treat all unknown or unfamiliar chemicals or substances as hazardous.
- Assume that a mixture of chemicals is more hazardous than its most hazardous component.
- Never use any substance that is not properly labelled.
- "There are no harmless substances, only harmless ways of using substances" Emil Mrak (1901–1987)

Minimize Exposure to Chemicals

- Avoiding or minimizing contact with chemicals through inhalation, injection, ingestion, or absorption via the skin or eyes, is the most efficient way to protect.
- The relationship between exposure and effect or response is well defined in toxicology and is summarized in dose-response or dose-effect curves with LD50 and LC50 as common measures of chemical toxicity. These curves demonstrate that all chemicals, given sufficient exposure, can cause harm. It is important, therefore, to minimize exposure to any chemical, regardless of its toxicity rating.
- With dose-response curves we recognize that relatively 'safe' chemicals can cause harm if we are subjected to a large enough exposure, however, it is also clear that relatively 'toxic' chemicals can cause little harm if exposure is prevented or sufficiently small. Exposure to any chemical, even relatively safe chemicals, must be minimized because of the potential for systemic accumulation and complicated interactions with other chemicals. The following are general precautions that should be taken to reduce chemical exposure:
- Where possible, substitute for a less hazardous chemical in analytical procedures. Always evaluate substitutions before making changes to procedures.

Engineering Controls

- Fume hoods are a primary means of controlling and preventing exposure, especially by inhalation, to airborne chemicals and should be used when working with chemicals and other harmful substances.

Administrative Controls

- Read and familiarize yourself with MSDSs/SDSs for all chemicals required in your work.
- Develop written SOPs outlining the steps in analytical processes which would make it easier to perform hazard assessments and can be modified to include methods for controlling identified hazards.
- Train workers, or ensure that you are trained, to perform procedures properly and safely.

SOPs can be especially useful as training documents.

- Maintain good personal hygiene and a clean workspace to reduce the chance of accidental exposure.
- Wash hands thoroughly after working with chemicals, even if gloves were used.
- Wash hands before leaving the lab, especially prior to consuming food or beverages.
- Wipe chemical drips/residues from containers and work surfaces.
- Avoid ingestion by not pipetting by mouth, and by not eating, drinking, chewing gum, or applying cosmetics while near or within chemical use or storage areas.
- Cell phones and use of music headphones should be avoided while working in the lab. The distraction can increase the potential for an accident and they can become contaminated if handled while working with chemicals.
- Use good laboratory practice as outlined in basic laboratory safety.

Personal Protective Equipment (PPE)

- Good personal hygiene and the proper use of PPE are important measures for preventing unintentional chemical exposure, especially those contaminating laboratory surfaces.
- PPE can also help to prevent contamination outside the laboratory by protecting your personal clothing.
- Appropriate PPE is essential for worker protection and is best used in combination with controls such as fume hoods and safe work practices.
- Alberta OHS legislation requires that all skin be protected from harmful substances that may injure the skin on contact, or may adversely affect health if absorbed through the skin. Full skin coverage is required at all times in the laboratory.
- Minimum PPE, including floor length pants, closed-toe shoes, safety glasses with side shields, and laboratory coats must be worn at all times in the laboratories.
- Protection must be upgraded if determined to be necessary by a hazard assessment.

Transporting Chemicals

- Many chemical spills occur as a result of improper transport within and between laboratories.
- Carry glass containers in specially designed bottle carriers or a leak resistant, unbreakable secondary container.
- Use a cart when transporting large, heavy or multiple containers. The cart must have high edges or secondary containment that will control any spills or leaks.
- Use a gas cylinder handcart when moving large gas cylinders. Ensure the cylinder is securely strapped to the cart.

Decanting Chemicals

- Ensure that the receiving container is large enough and is not overfilled.
- Use spill containment trays to catch leaks and spills when transferring liquids.
- When transferring liquids from large containers, use pump or siphons (not initiated by mouth) instead of pouring.
- When transferring flammable liquid from drums, ensure that both the drum and receptacle

are grounded and bonded together to avoid an explosion initiated by a static electric spark.

Handling & Use

- Observe basic laboratory work safe procedures – e.g. add acid to water, not water to acid
- Work in a fume hood whenever possible.
- Inspect laboratory glassware for cracks or defects before using it.
- Secure flasks and beakers to prevent them from tipping over.
- Ensure the work area is free of unnecessary clutter.
- Select equipment that has a reduced potential for breakage (e.g. Pyrex).
- Close chemical containers securely
- Keep the outside of containers clean and free of drips etc.
- Keep chemical containers tightly closed when not in immediate use.

Chemical Storage

- Proper storage is essential to reducing hazards associated with chemicals in the laboratory, especially in the event of accidental spill, break or leak. In academic laboratories, it is not necessarily the amount of individual chemicals that is of most concern; it is the number and the variety of different chemicals, especially if chemicals with incompatible properties are stored within close proximity of each other.
- Inadvertent mixing of chemicals can result in fires, hazardous fumes/gases/vapors, and explosions.
- Laboratories are encouraged to purchase only the quantities of chemicals needed for immediate use. Long term storage of chemicals is not advised.
- Segregation of chemicals in storage, based on hazard category and compatibility, is essential to reduce or eliminate hazardous chemical reactions. Check labels, MSDSs/SDSs, and chemical incompatibility charts to determine best storage practices. Separate each group from the others by one of the following methods:
- Chemicals with a low risk can be stored together on open shelving. Dry chemicals with different compatibilities can be separated by shelf or by separate areas of a shelf.
- Use physical barriers such as different cabinets, cabinet dividers, or shelves with spill containment.
- Use compatible secondary containment (trays, or buckets) large enough to contain the material in the event of a spill.
- Store chemical groups far enough away from each other to ensure that no mixing occurs.
- Store hazardous materials, especially liquids (including squeeze bottles), in secondary containment to minimize the spread of spills in the event of a broken or leaking container.
- Secondary containment is a means of containing and controlling chemical spills to reduce the risk of chemical exposure, fire, explosion, etc. Secondary containment containers must be made of materials that are resistant to the chemicals contained in them.
- Properly label all containers containing chemicals. Labels must be securely attached and legible.
- Exposure to heat or direct sunlight should be avoided to prevent degradation of chemicals and/or deterioration of storage containers (making them less susceptible to breakage).

- Chemicals should not be stored higher than eye level (of the shortest person). Do not store liquid chemicals above counter top level without a raised lip on the shelf or secondary containment. Store large bottles and containers, and heavy materials, on lower shelves.
- Chemicals must never be stored on the floor, even temporarily, because they could be knocked over and broken.
- Chemicals must not be stored in fume hoods because their containers block proper air flow, reduce available work space, and exacerbate hazards in case of fire or spill.
- Do not store chemicals under a sink.
- Only compressed gas cylinders that are in use and properly secured should be kept in the lab.
- Stored chemicals should be inspected periodically for deterioration and container integrity. Check that caps and closures are secure and free of deformation. Ensure that metal containers are free of rust, bulges or signs of pressure buildup.

Be Prepared for Accidents

- In addition to more obvious hazards, your workspace should be examined to identify measures that can be taken to prevent chemical exposure through an accidental spill or release.
- Continued vigilance is required to detect and correct unsafe conditions as they occur.
- You should be focused on your work - Cell phones and music headphones can be distracting, increasing the potential for an accident, and should be avoided while working in the lab.
- Be aware of the location, and have access to, all necessary emergency equipment, including spill kits, fire extinguishers, emergency showers and eyewash stations before you start working with chemicals

Flammable and Combustible Liquids

Flammable and combustible liquids are those that exist at room temperature in a liquid form with sufficient vapor pressure to ignite in the presence of an ignition source. Hazards associated with these chemicals are related to their high volatility and they become increasingly hazardous at elevated temperatures due to more rapid vaporization.

Fire/Explosion Hazards

- Flammable and combustible liquids are classified according to flash points; the minimum temperature at which a sufficient vapor is given off to form an ignitable vapor:air mixture.
    - Flammable Liquids - flash points below 38 °C (100 °F).
    - Combustible Liquids - flash points above 38 °C (100 °F).
- Flammable/explosive limits represent the range of vapor:air mixtures that will sustain combustion - Lower Explosive Limit (LEL) to Upper Explosive Limit (UEL).
- Liquids with broad ranges (e.g. acetylene; LEL = 3%, UEL = 65%) are more dangerous because explosion can occur at almost any vapor:air combination.
- It is not the liquid itself that burns; it is the vapors from the liquid that burns. Vapors from flammable/combustible liquids can reach remote ignition sources causing fires.
- Flammables with vapor densities greater than 1 (heavier than air) can accumulate in sufficient concentrations at floor level to ignite and spread through the room.

Health Hazards

Acute health effects:
Inhalation – headache, fatigue, dizziness, drowsiness and loss of cognitive function and consciousness. Irritation of mucous membranes. CNS depression and coma.
Ingestion – gastrointestinal irritation, abdominal pain, dizziness, fatigue, convulsions and vomiting.
Skin – burning sensation with drying, cracking, chapping of the skin. Defatting and drying of the skin. Absorption may lead to edema, blurred vision, liver damage, kidney failure.
Eye – stinging, watering eyes and inflammation of the eye lids.

Chronic health effects depend on duration and extent of exposure, but can lead to damage of the lungs, liver, kidneys, heart or CNS.
Potential to cause cancer and have reproductive effects. Prolonged exposure can lead to liver or kidney damage.
Liquid solvents have exposure limits. In many cases, e.g. chloroform, benzene, dichloromethane, etc., the odor threshold is higher than the exposure limit so if you can smell them you may be overexposed.

Handling and Use (Hazard Control)

- The three requirements for a fire (the fire triangle) are fuel, in sufficient concentration to ignite and sustain combustion, an oxidizer or oxygen, and an ignition source. When working with flammable and combustible liquids it is important to control and prevent significant accumulation of vapors and avoid ignition sources. The following precautions should be taken:
- Substitute with safer alternatives – higher flashpoints, higher boiling points, etc.
- Work in a fume hood - good ventilation is needed to minimize the risk of inhalation and to prevent the formation of flammable or explosive mixtures in air.
- Use only in areas free of potential ignition sources (open flames, electrical equipment, static electricity, hot surfaces, etc.). Never heat flammable liquids with an open flame.
- Avoid working with flammable liquids and oxidizers in close proximity.
- Never transfer, work with, or store flammable liquids in an area where a spill could block an exit in the event of a fire.
- In addition to basic laboratory PPE, a fire resistant or, at the very least, a cotton lab coat should be worn. Synthetic and synthetic blend lab coats should be avoided.
- Consult compatibility charts to determine the gloves that will provide the best hand protection.
- Flammable and combustible liquids must be maintained in approved flammable storage cabinets or safety cans. The amount of flammable and combustible liquid kept in the laboratory should be kept to the minimum necessary for the work being done.
- Do not store near oxidizers, corrosives, combustible material, or heat sources.
- When necessary to refrigerate flammable or combustible liquids, explosion-proof refrigeration equipment must be used. Regular refrigerators have ignition sources such as the door light switch and thermostat.

Corrosives (Especially Acids and Bases)

Corrosives are chemicals that cause rapid destruction of tissue at the site of contact (chemical burns)

and are potentially some of the most hazardous chemicals encountered in the laboratory. While acids and bases are the most common corrosives, some oxidizers, dehydrating agents and organics are capable of similar effects. Corrosives can be liquids, solids and gases.

Physical Hazards

- Reactions of corrosives with each other or with organic material create a considerable amount of heat, and potentially cause fire, that may cause burns.
- Dilution of acids and bases is exothermic and can cause burns.

Health Hazards

- The extent of the injury depends on the type and concentration of the chemical, the route of exposure, the type of tissue contacted, and the speed at which emergency measures are applied.
- Corrosives in the liquid and vapor state are highly irritating to eyes, skin and the respiratory tract. Direct contact can result in rapid visible destruction of tissue, including burning, redness, swelling, and painful blisters.
- Acids are most likely to cause immediate pain upon contact while contact with bases, recognized by the slippery soapy feeling, is less noticeable since pain does not occur immediately.
- Corrosive solids and their dusts can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled.
- Inhalation of corrosives such as fumes, dust, mist or gas cause difficulty breathing and coughing and can lead to pulmonary edema (severe irritation of the lungs resulting in fluid production that prevents the transfer of oxygen to the bloodstream).
- Effects of ingestion range from irritation to severe burns of gastrointestinal tract with nausea, vomiting, diarrhea, convulsion, and possibly death.
- The eyes are the most susceptible with exposure leading to stinging, watering of eyes, swelling of eyelids, intense pain, ulceration of eyes, and potentially loss of eyes or eyesight. Flush eyes immediately with water for at least 15 minutes if exposure occurs.

Handling and Use (Hazard Control)

- Hazard control must focus on efforts to avoid chemical burns by preventing skin and eye contact and to eliminate the potential for inhalation.
- Always work with corrosives in a chemical fume hood to vent any airborne hazards (fumes, gases, vapors, and mists) that are produced during procedures.
- Be aware of the locations of eyewash stations and safety showers before work begins.
- Dilution of acids and bases is exothermic, therefore, always add acids and bases to water. Never add water to acids and bases. Decant down the side of receiving containers to slow mixing.
- Use heat resistant glassware.
- Clean up any spills or leaks immediately.
- Wipe drips from containers and bench tops to avoid drying and buildup. Contact with dry residue can result in a burn.

- Always wash hands immediately after using corrosives, even if gloves were worn, and before leaving the lab.
- Basic laboratory PPE should be augmented with splash goggles, face shields, and rubber aprons when appropriate, especially when working with large volumes.
- Consult compatibility charts to identify gloves that will resist penetration from the specific corrosive chemicals used.
- Ideally, corrosives are stored in approved corrosive (acid/base) cabinets. When this is not possible, keep them on shelves closest to floor level.
- Acids and bases react with metals which can corrode nonresistant shelving, and other materials in their vicinity.
- Store strong acids and bases separately. Reactions can occur between vapors resulting in the formation of potentially hazardous precipitates on the outsides of bottles and in storage areas.
- Store liquids in secondary containers such as plastic trays to contain leakage.
- Store nitric acid and perchloric acid apart from each other and other corrosives.
- Flammable acids (e.g. acetic acid) should be stored with flammables.

Oxidizing Agents (Oxidizers)

An oxidizer is a chemical that is usually not itself combustible or flammable, but that initiates or promotes combustion in other materials through oxidation reactions. The intensity of the reaction depends on the oxidation-reduction potential of the materials involved; fire or explosion is most possible when strong oxidizing agents come into contact with easily oxidizable material, such as metals, metal hydrides or organics, especially flammable organic solvents. Exposure to heat, shock or friction can increase the explosive potential.

Physical Hazards

- Oxidizing materials can decompose readily at room temperature, or with slight heating, to produce oxygen. Elevated oxygen environments increase the risk of fire and explosion.
- When in contact with incompatible materials, oxidizers can:
    - Speed up the development of a fire and make it burn more intensely.
    - Cause materials that are normally not readily combustible in air to burn more readily.
    - Cause combustible materials to burn spontaneously without a source of ignition.
- Incompatible materials include paper, wood, flammable and combustible chemicals, grease, waxes, cloth and many plastics that can act as a source of fuel.
- Inorganic peroxides react vigorously with water to release oxygen. Contact with organics and other oxidizable materials can result in fire.
- Organic peroxides (carbon-based compounds containing peroxi groups: -O-O-) are unstable, highly reactive and extremely flammable in the dry crystalline state. They are sensitive to heat, friction, impact, light and strong oxidizing agents
- Nitrates enhance the combustion of other materials and can give off irritating or toxic fumes in a fire. Some nitrates become shock sensitive when mixed with organic materials.
- Perchlorates are normally stable, but may become explosive when mixed with combustible materials.

Health Hazards

- In general, oxidizers are corrosives and have similar health hazards to corrosives.
- Contact with skin causes redness, irritation, and possibly burns.
- Inhalation may cause respiratory tract irritation, sore throat, and possible burns. May lead to nausea, dizziness, drowsiness, headache, shortness of breath, rapid heart rate, pulmonary edema, or death.
- Ingestion may cause severe digestive tract irritation, nausea, vomiting, and burns potentially leading to severe and permanent damage or death.
- Chronic health effects are related to hematological and neurological changes. Absorption of some oxidizers has been associated with liver and kidney disease and cancer.

Handling and Use (Hazard Control)

- All procedures involving oxidizers should be performed in well ventilated areas, preferably in a fume hood, to prevent a buildup of oxygen.
- Safety shields should be used when reactions are expected to be highly exothermic or if there is a risk of splash or explosion.
- Follow these safe work practices:
    - The quantity of oxidizer should be kept to the minimum necessary for the procedure. Do not leave excessive amounts in the vicinity.
    - When working with, or storing, oxidizers it important to keep them away from all combustible materials including paper, wood, flammable and combustible chemicals, grease, waxes, cloth and plastics that are sources of fuel.
    - Do not use oxidizers around open flames or oil baths (source of fuel). When necessary, heat reactions involving oxidizers with heating mantles, water baths or sand baths.
    - Even a trace contamination of a stock container of oxidizing material can lead to fire or explosion. To avoid contamination, transfer the required amount to a secondary container and do not return unused material to the original container.
    - Remove contaminated clothing, footwear etc. as they can pose fire hazards.
    - Be sure that oxidizers are not shock sensitive before chipping or grinding lumps to break them up. If crystals have formed in containers, get help for safe handling and disposal.
    - Store oxidizers in containers made of inert material, such as glass, on fire resistant shelving.
    - Do not store in the same area as potential fuel sources and keep segregated from dehydrating agents (e.g. sulfuric acid) and reducing agents.
    - Do not use organic material, such as paper towels, to clean up spills.

Working with Perchloric acid

- At room temperature and at concentrations less than 72%, perchloric acid is a corrosive like most other strong acids. At increasing concentrations or with heating, perchloric acid becomes a strong oxidizer that is prone to spontaneous and explosive decomposition. Anhydrous perchloric acid (> 85%) is very unstable and may explode when it comes into contact with organic materials.
- ***All work with perchloric acid should be performed in a Perchloric Acid Fume Hood.***

- Perchloric Acid Fume Hoods are made of stainless steel (no wood) and have a water flush system to prevent the buildup of perchloric acid crystals.
- When possible, substitute with less hazardous chemicals or use more dilute solutions (< 60%).
- Always maintain perchloric acid in an appropriate secondary container away from all other chemicals and organic materials, including wood, paper, and cloth.

Particularly Hazardous Chemicals

The use of particularly hazardous chemicals requires extra safety precautions and work with these chemicals should only be done after consultation with your supervisor. Users must be aware of the hazards posed, prior to working with these chemicals and may require extra or specialized training.

Work with these chemicals must be in designated areas and it is important that those around you are informed of the materials that you are working with so that that they too can take proper precautions.

- Toxic or Highly Toxic Chemicals – chemicals with high acute local or systemic toxicity, or chronic toxic effects such as carcinogens, reproductive or developmental toxins, and mutagens.
- Highly Reactive and Explosive Chemicals - chemicals that have the potential to vigorously polymerize, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. The result is generally a violent release of energy with a large volume of gas, heat, and possibly toxic vapours. Failure to observe the appropriate handling procedures can lead to fire or explosion that can cause serious injuries and property damage.
- Explosives Chemicals (Shock/Heat Sensitive) - chemical that causes sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock, detonation, and certain catalysts can initiate explosive reactions. Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide, or ozonide are sensitive to shock and heat and can explode violently.
- Pyrophoric Chemicals - ignite spontaneously when exposed to air. Also tend have corrosive, water reactive, and peroxide forming properties.
- Water Reactive Chemicals - react with water or moisture in the air to give one or more of the following outcomes:
    - Liberation of heat, which can cause the ignition of the chemical itself, if it is flammable, or other flammable chemicals nearby.
    - Release of flammable, toxic or strong oxidizing gases.
    - Formation of corrosive acids.
    - Alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, and peroxides are water reactive.
- Peroxide-Forming Chemicals. A number of chemicals can become dangerous with age due to a tendency to form peroxides when exposed to air, moisture, and other impurities. Peroxides, and the chemicals that contain them, are sensitive to heat, shock and friction, and may explode violently. Organic Peroxides are some of the most hazardous chemicals used in laboratories because, in addition to being sensitive, they readily react with oxidizing and reducing agents and are highly flammable. There are

three groups of peroxides:

- Spontaneously form peroxides with exposure to air without further evaporation or concentration. Test for peroxides or dispose of within 3 months of opening.
- Form peroxides only upon concentration by evaporation or distillation. Test or dispose of within 1 year of opening.
- Monomers that form peroxides that may act as a catalyst, resulting in explosive polymerization.
- The more volatile the compound the greater the hazard because evaporation allows the peroxide to concentrate.
- Protect containers from heat sources and physical damage.
- Do not store peroxide forming chemicals at low temperatures where peroxides may precipitate out, making them more susceptible to shock. When necessary to cool, an explosion proof refrigerator must be used.
- Inspect the containers of peroxide forming chemicals frequently for signs of peroxide accumulation. If any of the following are present, do not move the container and seek help with removal:
  - Liquid chemicals: Look for crystal formation around the cap or in the liquid itself, discoloration, or viscous liquid at the bottom of the container.
  - Solid chemicals: Look for discoloration or a surface crust.

Assessing Chemical Hazards

- MSDS/SDSs are an invaluable source of information when assessing the hazards associated with particular chemicals. National Fire Protection Agency (NFPA Diamond) and the National Paint and Coatings Association (Hazard Management Information System – HMIS® III) provide independent assessment of chemicals that make an evaluation of their hazards much more convenient. In both systems chemicals are rated between 0 and 4 for each potential hazard; health, flammability and reactivity (physical). The NFPA and HMIS® ratings can be found on most MSDSs. While both systems are effective, the HMIS® III has two important advantages, both related to health ratings, for academic laboratories:
  - HMIS® III rates the hazards of chemicals at the bench. The NFPA ratings are intended for first responders and rate chemicals under emergency conditions such as fire.
  - HMIS® III provides a Chronic Hazard Indicator which identifies chemicals for which there is health effects associated with long term, or repetitive exposures.

- Ratings for Flammable and Physical (Reactivity) hazards of chemicals are similar for the two rating systems. A more detailed description of the criteria used for Physical hazard ratings for individual classes of chemicals (water reactive, organic peroxides, explosive, compressed gases, pyrophorics, oxidizers, and unstable reactives) can be found in HMIS® Implementation Manual (third edition). The HMIS® Health, Flammability, and Physical hazard ratings are presented below.
- The HMIS® and NFPA ratings are useful indicators of the risk of working with a particular chemical. However, a consideration of the amount of the chemical that a worker could be exposed to (the potential dose) is necessary to assess the potential hazard of working with that chemical.

- As indicated by dose-response curves, the size of a chemical exposure determines the extent of harm; from benign, to therapeutic, to harmful, to deadly. Similarly, small amounts of an explosive chemical may result in little more than a 'POP" when detonated, while the detonation of large quantities could result in considerable damage and injury.
- In general, the greater the amount of a chemical present, the more likely a health, flammable or reactive event will occur and the more severe the effects will be. Thus, the potential hazard of working with a highly hazardous chemical is reduced by drawing from smaller stock quantities (1 g stock rather than a 100 g stock). The potential hazard of working with less hazardous chemicals can be increased by the presence of large quantities (e.g. 4 L bottle rather a 500 mL bottle). An example of a rating for exposure based on chemical amount/volume is provided below. An example of a hazard assessment for chemicals is provided in Appendix 2.

HMIS: Health Hazard Rating Chart

Chronic Hazard – Chronic (long-term) health effects may result from repeated or long-term overexposure.

0 = Minimal Hazard - no significant health risk; no effect anticipated; practically nontoxic; irritation of skin or eyes not anticipated

1 = Slight Hazard - irritation or minor reversible injury may occur; may irritate the stomach if swallowed; may defat the skin and exacerbate existing dermatitis

2 = Moderate Hazard - temporary or transient injury may occur; prolonged exposure may affect the CNS and lead to apparent intoxication, nausea, headache, dizziness, weakness or fatigue.

3 = Serious Hazard - major injury likely unless prompt action is taken and medical treatment given; high level of toxicity; corrosive.

4 = Severe Hazard - life-threatening; major or permanent damage may result from single or repeated overexposures; extremely toxic; irreversible injury may result from brief contact.

HMIS: Flammability Hazard Rating Chart

0 = Minimal Hazard - Materials that will not burn.

1 = Slight Hazard - Materials that must be preheated before ignition will occur, including liquid, solid and semi-solid chemicals with a flash point above 200 °F (Class IIIB).

2 = Moderate Hazard – Materials that must be heated moderately or exposed to high ambient temperatures before ignition will occur, including liquid chemicals with a flashpoint at or above 100 °F but below 200 °F (Classes II & IIIA).

3 = Serious Hazard - Materials capable of ignition under almost all normal temperature conditions. Includes flammable liquids with flash points below 73° F and boiling points above 100 °F as well as liquids with flash points between 73 °F and 100 °F (Class IB & IC).

4 = Severe Hazard - Materials may ignite spontaneously with air. Flammable gases, or very volatile flammable liquids with flash points below 73 °F, and boiling points below 100 °F (Class IA).

HMIS: Physical Hazard Rating Chart

0 = Minimal Hazard - Materials that are normally stable, under fire conditions and will not react to water, polymerize, decompose, condense or self-react.

1 = Slight Hazard - Materials that are normally stable but can become unstable at high temperature and pressures. Materials may react non-violently with water or undergo hazardous

polymerization in the absence of inhibitors.
2 = Moderate Hazard - Materials that are unstable and may undergo violent chemical change at normal temperature and pressure with low risk for explosion. Materials may react violently with water or form peroxides upon exposure to air.
3 = Serious Hazard - Materials that may form explosive mixtures with water are capable of detonation or explosive reaction in the presence of a strong initiating source or undergo chemical change at normal temperature and pressure with moderate risk of explosion.
4 = Severe Hazard - Materials that are readily capable of water reaction, detonation or explosive decomposition at normal temperatures and pressures.

Potential Dose Rating

Exposure (Dose) based on the amount of chemical in the worker's presence, not simply the amount used in a reaction or procedure (based on U of A HSE Spill Response Guidelines).
High = High Exposure – For Stock Chemicals/Solutions: Flammable liquids more than 500 mL; all other Chemicals more than 1 L liquid or 500 g solid (Spill is considered by U of A HSE to be an Emergency).
Med =Moderate Exposure - Stock Chemicals/Solutions: Flammable liquids between 100 mL and 500 mL; all other chemicals between 100 mL and 1 L liquid or between 50 and 500 g solid
Low = Low Exposure - Stock Chemicals/Solutions: Flammable liquids less than 100 mL; all other chemicals less than 100 mL liquid or 50 g solid.

Chemical Spill Protocol

Every lab must have a stocked chemical spill kit appropriate for the hazards and chemicals used in that lab. When a Chemical spill occurs, contact Kelvin Lien (kelvin.lien@ualberta.ca, 780-289-1552), Brett Feland (brett.feland@ualberta.ca, 780-492-8435), or Urmila Basu (ubasu@ualberta.ca, 780-492-8712) for assistance. Spills must be reported to HSE via the online incident reporting tool. The University of Alberta Chemical Spill Response protocol is found on the HSE website (https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/hazard-management/what-are-my-hazards/chemical.html).

Spill Clean Up Equipment

Chemical absorbent (20 L)
Plastic pail (20 litre) with lid (2)
Felt marking pen (2)
Heavy Plastic Bags; at least 3 mil thickness (12)
Plastic bucket with handle (1)
Long handle sponge mop (1)
Extra sponges (4)
Plastic dust pan (1)
Broom (1)
Duct tape (roll)
Detergent (box)
Citric Acid (500 g)
Sodium Bicarbonate (500 g)

Sodium Thiosulfate (500 g)
Spill Response Guideline

Biological Safety - Controlling Biological Hazards

Ag/For Biosafety Inquiries

Heather Vandertol-Vanier, M.Sc.
Biosafety Technologist, 2-58E Agriculture/Forestry Centre
Tel: 780-492-7659
E-mail: hav2@ualberta.ca

Contacting the Biosafety Division

Department of Environment, Health and Safety
3-107 Research Transition Facility Edmonton, AB Canada T6G 2V2 Fax: 780-492-7790
E-mail: biosafety@ualberta.ca

Biohazardous Agents and Activities

Pathogenic Microbes
Eukaryotic Cell Lines
Biological Toxins
Human Clinical Specimens & Body Fluids
Animal Tissue
Genetically Modified Organisms (GMO's)
Viral-based Recombinant Vector Systems
Infectious RNA
Non-Indigenous Plant, Insect or Animal Species

Registration of Biohazards

All groups conducting research involving biological materials in laboratory space owned by the U of A, must register on the HSE database and follow the University of Alberta Biosafety Guidelines.
All members of a research group working with biohazardous agents must be added to the HSE database. Biosafety registrations must be updated annually.
https://arise.ualberta.ca/ARISE/sd/Rooms/DisplayPages/LayoutInitial?Container=com.webridge.entity.Entity[OID[AC482809EC03C442A46F2C8EEC4D75D3]]

Biological Transfers

Transfers of regulated biological materials within Canada and internationally must be reported to the Biosafety Officers. Transfers require appropriate accompanying documentation. Do not attempt to send or receive biological samples without applying for approval by Biosafety at the University of Alberta. Before placing an order or preparing a shipment, report all transfers of biological materials to and from campus to HSE by selecting "Request a biotransfer" in the HSE database. Provide the requested information. Biosafety personnel will assist you with the preparation and submission of any

relevant documents. Once the approval has been granted, notification will be sent to you along with shipping instructions. Shipments must be prepared or received by a person who has Transportation of dangerous goods certification.

Biosecurity

- Ensure laboratory doors are locked when personnel are not on site.
- Keep laboratory doors closed.
- Lock fridges and freezers containing archived biohazardous agents and located outside the common laboratory work areas in cross-corridors or communal storage rooms.
- Lock cold rooms and warm rooms located off non-secure public and semi-public hallways.
- Report suspicious behavior or unauthorized personnel loitering around laboratory spaces to Protective Services.
- Report evidence of attempted forced entry to Protective Services.
- Report missing stocks of biohazardous agents to PI and if the stock is still unable to be located immediately file an Incident Report with HSE.
- Ensure laboratory keys are returned or access is removed from swipe cards when personnel leave the group or no longer require access to the area.

Laboratory Access

Access to laboratories where biohazardous agents are handled and stored is restricted to authorized personnel. Personnel who have completed the proper orientation and training may work independently and unsupervised in the laboratory. All other personnel may only enter the laboratory under the escort of someone who has completed this training.

Training and Orientation of Personnel

Outlined below is the minimum training requirement for any University of Alberta personnel directly working with biohazardous materials (research or teaching).

- Workplace Hazardous Materials Information System Training – U of A online course
- Laboratory and Chemical Safety Course - U of A online course
- Concepts in Biosafety Course - U of A online course
- Laboratory specific orientation and training
- Experiment Specific orientation and training

All training must be completed prior to starting independent biohazardous work. All training must be documented.

Safety Data Sheets

SDSs (human and animal pathogens) and (biological toxins and cell lines) should be available in paper

or electronic format. Read the appropriate SDS for all biohazardous materials. SDSs can be found on the Public Health Agency of Canada website (http://www.phac-aspc.gc.ca/lab-bio/res/psds-ftss/index-eng.php).

Inventory of Biohazardous Agents

An inventory of biological materials is a federal requirement and must be maintained at all times.

- Items to be included in the inventory are as follows:
    - Biosafety Level 1 and 2 materials that are:
        - Stored at -70 ˚C or in a liquid nitrogen dewar.
        - Stored at 4 ˚C for more than one month.
        - Stored at room temperature in a non-metabolic state (i.e., spore slant, sealed lyophilized vial, etc.) for more than two weeks.
    - Ongoing cultures in an incubator are not considered archival stocks.
- The minimum record-keeping requirements for biohazardous materials include:
    - Genus and species
    - Location where stored
    - Number of containers of each biohazardous agent
    - Date of receipt or generation
    - Risk level
    - If/when they are transferred to another group
    - Inventories can be kept as paper or electronic documents. Inventories must be kept up-to-date and must be made available on request to HSE personnel.
- Inventories should be verified at least once per year. Labs with substantial inventories are required to verify a subset of their inventory. This verification process must be documented.

Personal Protective Equipment for Biohazards

- Personal protective equipment must be worn by all employees, supervisors, volunteers and visitors. As with any other lab, long pants, closed toe shoes, lab coat, safety glasses and gloves must be worn.
- Some exceptions to these rules as are as follows:
    - When working with a microscope, safety glasses will impede your work so safety glasses can be removed.
    - It is unsafe to use a flame (e.g. Bunsen burner, alcohol burner) when wearing latex, nitrile or vinyl gloves. Gloves should be removed when working with open flame.
- When working with a respiratory pathogen, appropriate respiratory protective equipment must be utilized.
- Remove PPE (gloves, lab coat and safety glasses) when exiting the lab.

Personal Hygiene in the Lab

- Long hair must be tied back so that it does not fall into solutions or flames or contaminate work.
- Avoid touching the face, eyes and other direct routes of exposure.
- All open wounds should be assessed and the appropriate waterproof coverage must be worn to

prevent accidental contamination, or work must be postponed until the wound is healed.

- Hand washing should be done frequently during the day with soap and warm water. Hands should be washed when leaving the lab and after removing gloves before continuing any work. If there is a potential for contamination under the gloves, gloves should be removed as soon as possible and hands thoroughly washed with soap and water.

Personal Electronic Devices

If you choose to bring your own smart phones, computers or tablets into a biohazardous environment, be prepared to decontaminate that device prior to leaving the facility.
Decontamination can include wiping with a disinfectant or autoclaving the device.

Working with Biological Material – Best Practices

Aseptic techniques are practiced because they are procedures that protect the culture, the worker, and the environment. Good sterile technique is the first and most important step in ensuring consistent results. ALWAYS use aseptic technique when handling biological materials.
In general:

- Keep the work area as clean as possible. Reduce clutter.
- Work from "clean" area to "dirty" area.
- Ensure that all items required for work are available such as solutions, samples and equipment.
- Avoid producing excess aerosols by talking or laughing and excess movements.
- Do not use computers or tablets or other electronics at the work bench.
- Keep cultures/solutions closed as much as possible. Maintain an 45^{o} angle when cultures/solutions are open.
- Work quick but carefully and accurately.
- Always wash hands after removing gloves or after work is completed.
- Decontaminate the work area before and after working.
- Leave your lab coat in the lab.
- Because contaminating bacteria are ubiquitous and are found on fingertips, bench tops, etc., it is important to minimize contact with these contaminating surfaces.
- Use a flame on inoculating loops and on the lips of tubes and media bottles before and after pipetting from them.
- Never leave a microbiological media or agar bottle open on the bench.
- Don't take an individually-wrapped pipette out of its protective wrapper until you are ready to use it.
- Always use a fresh, sterile pipette or pipette tip when pipetting culture media, and never go back into a media bottle or cell culture with a used pipette.
- To prevent wide-scale, untraceable contamination, each person should have his/her own stock of liquid culture media, top agar, plates, 100% glycerol, glycerol stocks of cells, etc.
- Think about what you are doing. The best defense is common sense.

Repair or Disposal of Equipment used with Biohazardous Agents

Any equipment that has been in contact with biohazardous agents must be decontaminated prior to being repaired or removed from the laboratory. To properly decontaminate research equipment

utilized with biohazardous material, follow the instructions given in the Equipment Decontamination Form as found on the HSE website (https://docs.google.com/document/d/1_X2WvmQZ47Fk_BG71FQPi8sn_JS3iZrXY-vamo_tQAk/edit).

Transporting Level 1 and Level 2 Biological Materials

There are specific guidelines for transporting Level 1 and 2 biological materials. Precautions must be taken to ensure that biological material is transported safely. All materials must be transported in a primary container in good condition with a tightfitting lid. Transport biological materials directly to the delivery destination.

Between adjoining lab spaces on the same floor: Properly packaged materials may be transported using a cart. Wear proper PPE leaving one hand ungloved to touch communal surfaces such as door knobs.

Between floors in a building: Properly packed materials may be transported between floors on a cart. Appropriately label the package with all hazards. Liquids must be placed in a secondary container with appropriate amounts of absorbent material. Wear proper PPE leaving one hand ungloved to touch communal surfaces such as door knobs and elevator buttons. Use a freight elevator, if one is available.

Between U of A Buildings (on foot)*:* Place the materials in a ziplock bag, decontaminate the outside of the bag and label with name, date and sample contents and any WHMIS symbols. The bag is then placed in secondary containment such as a cooler with a water tight lid. This should be labelled with the PI name and phone number. Do not wear any PPE when transporting the biological material. Only use PPE to pack and unpack the biological materials.

Transfer of Biohazardous Agents off Campus or Between U of A Campuses: Transporting biohazardous materials off campus and between U of A campuses must be done using Transportation of Dangerous goods.

If a spill should occur during transport either call F&O control centre (780-492-5555) or to a trained spill designate in the department. Contact Heather Vandertol-Vanier at 780-492-7659 or hav2@ualberta.ca for assistance with cleaning a biological spill. Do not leave the spill site until it has been cleaned. File an incident report with HSE as soon as possible.

Safe Handling of Laboratory Equipment

SOPs for departmental equipment are found on the AFNS safety drive. Using equipment with biohazardous materials requires some special considerations. Below are some special considerations for the most commonly used equipment in Level 1 and 2 labs.

Biosafety cabinets

All biosafety cabinets must be tested annually. Arrangements will be made through HSE with the person responsible for the biosafety cabinet. As well, before a biosafety cabinet can be moved or repaired it must be decontaminated by HSE. Once the cabinet has been moved or repaired the biosafety cabinet must be tested to ensure proper functioning.

Prior to using a biosafety cabinet, all personnel must be properly trained. If you would like training, contact Heather Vandertol-Vanier at 780-492-7659 or hav2@ualberta.ca to make arrangements for training.

The static pressure must be recorded on a log sheet every time the biosafety cabinet is turned on. Monitor the pressure to ensure that there isn't a significant change. Changes of greater than ±0.25 must be reported to the person in charge of the biosafety cabinet as this may indicate a malfunction. Put the cabinet out of service and inform HSE.

Biological safety cabinets should be used when working with pathogens, tissue culture and human samples.

Preparation

- Turn on fluorescent lights
- Check air grilles for obstructions, switch on blower
- Allow air to purge workspace for 5 minutes
- Record the static pressure
- Spray or swab all interior surfaces with appropriate disinfectant

Assemble Material

- Preplan and have all supplies ready for the entire procedure
- Introduce only material required to perform procedure (do not block air intake or exhaust grill by over filling the cabinet)
- Place material such that clean and contaminated items do not meet
- Place contaminated material container at right rear
- Purge (pre-use)
- Allow air purge period with no activity inside (leave blower on!)
- Wear protective clothing, gloves, mask, etc. as appropriate

Perform Procedures

- Introduce hands into work space, work carefully and methodically (i.e. from clean to work area to discard)
- Do not rest arms on grills
- Work towards the centre of the cabinet to ensure adequate protection
- DO NOT remove hands from work space until procedures are complete and all critical material is secured
- Remove gloves into contaminated material container
- Purge (Post-use)
- Allow air purge period with no activity inside (leave blower on!)
- Terminal Disinfection
- Use fresh gloves, remove materials to incubator, to biohazard bag, autoclave as appropriate
- Spray or swab all interior surfaces with appropriate disinfectant

Shutdown

- Turn off blower
- Replenish communal supplies
- Refill the bottle of disinfectant, put a new plastic bag in the waste bucket

Other helpful hints with biosafety cabinets

- Keep activity in the area surrounding the hood to a minimum to reduce the amount of air disruption in the hood.
- Place everything at least 4" inside the work area to reduce chance of contamination.
- If a spill occurs clean it up immediately before continuing work.
- Never use an open flame in a biosafety cabinet.
- Every time the cabinet is used, record the static pressure on the chart provided by HSE.

What to do in case of a cabinet failure while working

- Seal containers, surface decontaminate and remove any biohazardous material.
- Decontaminate the interior of the BSC.
- Switch off the power if the motor is making noise.
- Place a sign on the cabinet to indicate that it is broken and must not be used.
- Contact Heather Vandertol-Vanier (hav2@ualberta.ca).
- If personnel may have been exposed to infectious material due to cabinet failure, then the supervisor must be promptly notified and an incident report completed and the appropriate first aid and medical follow-up action taken.

Clean air benches

Clean air benches are not biological safety cabinets and should never be used with pathogens or other materials that are potential aerosol hazards. These benches only protect the product not the user.

Autoclaves

Autoclaves are used to sterilize items potentially exposed to biohazards. Autoclaves operate with steam and pressure. Both of these can be dangerous, so autoclaves should be used with caution. Before using any autoclave, you must receive training from Urmila Basu, Kelley Dunfield, Brett Feland, Heather Vandertol-Vanier or Yanhong Chen.

- When loading an autoclave, do not overload by stacking or overflowing containers. Some general guidelines as follows:
    - Liquids
        - Containers should not be any more than 2/3 full.
        - Do not seal liquid containers when placing them in the autoclave. Loosely cover containers by placing caps over them without screwing them tight, or cover with a piece of aluminum foil.
        - Put in an autoclave safe container.
        - Be careful when removing to prevent bumping (liquid boiling over).
        -
    - Solid waste
        - Waste bags should be open so that steam can penetrate to sterilize all items.
        - Each cycle should be about 1 hour.

Important Safety Practices autoclaves

- Load the autoclave properly per the manufacturer recommendations.
- Before loading containers of liquids into the autoclave, the caps must be loosened.
- Use an autoclave safe tray with a solid bottom and walls to contain the bottles and catch spills.
- Don't load plastic materials that are not compatible with the autoclave.
- Individual glassware pieces should be within a heat resistant plastic tray on a shelf or rack and never placed directly on the autoclave bottom.
- Make sure the door of the autoclave is fully closed and the correct cycle has been selected before starting the cycle.
- Wear heat-resistant gloves when cracking the autoclave door open after a run.
- Before removing autoclaved items, wait 5 minutes for loads containing only dry glassware, and 10 minutes for autoclaved liquid loads.
- When removing items from the autoclave use heat resistant mitts.
- Be alert for autoclaved liquid bottles still bubbling. Let liquid loads stand in an out of- the-way place for a full hour before touching with ungloved hands. Hot glassware and scalding liquids will cause burns and serious harm.
- Do not autoclave items containing bleach or phenol.
- PPE including long pants, closed toe shoes, lab coat, safety glasses and heat resistant gloves should be worn when loading and unloading an autoclave.
- An SOP for using an autoclave is available on the AFNS safety drive.

Centrifuges

- High-speed spins generated by centrifuges can create large amounts of aerosol if a spill, leak or tube breakage occurs. An SOP for using centrifuges is available on the AFNS safety drive. To avoid contaminating your centrifuge:
- Check glass and plastic centrifuge tubes for stress lines, hairline cracks and chipped rims before use. Use unbreakable tubes whenever possible.
- Avoid filling tubes to the rim.
- Use caps or stoppers on centrifuge tubes.
- Use sealed centrifuge buckets or rotors which can be loaded and unloaded in a biological safety cabinet. Decontaminate the outside of the cups or buckets before and after centrifugation. Inspect o-rings regularly and replace if cracked or dry.
- Ensure that the centrifuge is properly balanced.
- Do not open the lid during or immediately after operation, attempt to stop a spinning rotor by hand or with an object or interfere with the interlock safety device.
- Decant supernatants carefully and avoid vigorous shaking when resuspending packed cells.
- Clean spills promptly.

Lyophilizers (Freeze-Driers)

- Aerosols may be produced during operation of a freeze drier and when material is being removed from the chamber. When lyophilizing biohazardous materials:
    - Load samples in a biological safety cabinet.
    - Check glass vacuum containers for nicks and scratches.
    - Use only glassware that was designed for high vacuum use.
    - Use a disinfectant-containing trap for the vacuum pump exhaust.
- After completion of the run, decontaminate all accessible surfaces.

Vacuum/Aspirating Equipment

- Glass vacuum vessels may rupture and shower laboratory personnel with glass fragments and flask contents. To reduce these risks:
    - Use metal flasks and vacuum traps whenever possible.
    - Tape glass containers with duct or adhesive tape to contain glass shards in case of rupture, or use a secondary metal container that is at least as tall as the vacuum flask.
- To prevent exposure of lab personnel or maintenance employees who may be required to repair the central vacuum system, vacuum line connections that draw biohazardous aerosols or fluids should be fitted with:
    - a HEPA filter in the line leading into the vacuum line: cartridge-type in-line filters provide an effective barrier to escape of aerosols into vacuum systems, and are commercially available for this purpose (discard used filters as biomedical waste)
    - an overflow flask in case of accidental aspiration of liquids out of the collection vessel. This flask should:
        - be of sufficient capacity
        - be placed between the collection flask and the air filter Filtration of biohazardous materials must be done in a biosafety cabinet

Needles and Syringes

- Needles and syringes present hazards of spill, autoinoculation and aerosol generation, and should be used only when absolutely necessary. When working with syringes and needles, the following precautions are recommended:
- Perform all operations with infectious material in a biological safety cabinet.
- Keep syringes and sharps pointed away from the worker and others.
- Fill syringes carefully; avoid frothing or introduction of air bubbles.
- Use luer-lock needles and syringes or units in which needles are integral to syringes. Do not bend, shear by hand, or recap needles.
- Do not disassemble a needle/syringe assembly.
- Place used needles and syringes in puncture-resistant containers and dispose of the container using Chematix.
- Incidents with needles must be reported to your PI as soon as possible and an incident report must be filled out and sent to HSE.

Pipettes

- Selection of a Mechanical Pipetting Aid
- Improper handling of pipettes can lead to contamination of the user and/or to generation of hazardous aerosols. Mechanical pipetting aids should be used for all pipetting procedures.
- Never pipette by mouth.
- Selection of a pipetting device should be based upon:
    - intended use
    - ease of handling
    - delivery accuracy
    - user preference
    - quality of seal formed with pipettes to be used; liquid should not leak from the pipette tip
    - whether the pipetting aid can be sterilized

Safe Use of Pipettes

- If infectious aerosols are likely to be generated, pipette in a biological safety cabinet. Handling pipettes as described below will reduce splashing and aerosolization:
- Plug pipettes with cotton.
- Check pipettes before using; cracked or chipped suction ends may damage the seals of the pipetting aid.
- Keep pipettes upright while in use and between steps of a procedure to prevent contamination of the mechanical aid.
- Gently expel contents close to the surface of a liquid or allow to flow down the side of the container.
- Avoid mixing fluids by alternate suction and blowing, or by bubbling air from the pipette.
- Avoid forceful ejection of the contents; use TD (short for "to deliver", also referred to as "mark-to-mark") rather than TC ("to contain") pipettes, as the last drop of fluid does not have to be expelled with TD pipettes.
- Use easier-to-handle shorter pipettes when working inside a biological safety cabinet.
- Submerge used non-disposable pipettes horizontally in disinfectant solution; dropping them in vertically may force out any liquid remaining in the pipette.

Miscellaneous Equipment

Microscopes

- Disinfect the stage, eyepieces, knobs and any other contaminated parts.
- Select a disinfectant that will be effective on the pathogens and non- corrosive to the microscope.

Water baths

- Clean regularly; add disinfectant, such as a phenolic detergent, to the water.
- Avoid using sodium azide to prevent growth of microorganisms because sodium azide forms explosive compounds with some metals.
- Raise the temperature to 90°C or higher for 30 minutes once a week for decontamination purposes.
- To prevent electrical shocks, unplug the unit before filling or emptying and have the

continuity-to-ground checked on a regular basis.

Tissue grinders/Homogenizers/Sonicators

- Allow aerosols to settler prior to opening vessels
- Use these in a biological safety cabinet when working with biohazardous material
- Wear gloves and hearing protection

Microbiological transfer loops

- To eliminate the spattering and aerosolization associated with flaming of loops, char the material before fully inserting the loop into the flame: i.e., before flaming, hold the loop close to (but not into) the flame. Alternatively, use disposable loops or a microincinerator.

Biohazardous Spill Protocols

When a biological spill occurs, contact Heather Vandertol-Vanier (hav2@ualberta.ca, 780-492-7659) for assistance. The University of Alberta Biological Spill Remediation protocol is found on the HSE website https://docs.google.com/document/d/1lC_DDftOOyELQv7d9wQP4iiOU-gy9WRn1lqLj5MdZ7o/edit

Biological Spill Kit

A biological spill kit must be available for all biohazardous lab spaces. The kit must be equipped as follows:

Dedicated mop and bucket
Jug of household bleach
Old bath towels (minimum three)
Package of J-cloths or box of cheesecloth
One pair large forceps
Face-shield or safety glasses
Two single-use self-adhesive N-99 respirators
Large garbage bags or clear autoclave bags
Copy of the biohazard spill remediation protocols below

Biohazardous Waste

All biological waste must be decontaminated by autoclaving, chemical decontamination or incineration.

Transporting biohazardous waste

When waste must be moved between rooms, a closed waste container must be placed in a leak proof container on a cart for transport. Do not carry the waste container. Biohazardous waste that has been decontaminated can be placed in the appropriate area (bags in the general garbage, glass in glass waste etc.). If waste cannot be decontaminated in the lab, it must be appropriately packaged and sent through Chematix for pickup.

Biohazardous waste accumulation

All biohazards must be segregated and decontaminated before disposal. The University of Alberta

Biosafety Manual (https://www.ualberta.ca/vice-president-finance/media-library/ualberta/vice-president-finance/environment-health-saftey/documents/biosafetyguidelines.pdf) has a detailed chart outlining how to appropriately accumulate, decontaminate and dispose of biohazardous materials.

If biohazardous materials must be stored before decontamination the following will apply:

- Up to 24 hours at room temperature
- Up to 42 days at 4°C
- Up to 90 days below 0°C

A few common procedures for biohazardous waste are briefly discussed below.

Accumulation and handling of solid biohazardous waste

Place a clear autoclave bag inside an orange biohazard bag to collect biohazardous material. When ~50% full, remove the bag and contents from the orange biohazard bag and place in an autoclavable tray. These are loaded into an autoclave and run on an appropriate biobag cycle. The top of the bag should be open to allow steam to penetrate inside.

Accumulation and handling of liquid biohazardous waste

Liquid waste is accumulated in autoclavable containers with lids. Label with your name, the date and what is in the waste. When autoclaving lidded containers, the lids must be loosened before autoclaving.

Cell culture waste

Cell line liquid waste is accumulated in a container, treated with 10% bleach for 30 min and poured down the sink with ample cold water. Waste must not accumulate more than one day. Solid cell culture waste should be accumulated in the same manner as solid biohazardous waste.

Animal waste

Animal carcasses and human specimens must be collected in yellow biohazard pails with sealable lids. When the buckets are 2/3 full, seal the lids and use Chematix for disposal.

Mixed waste

Biohazardous materials that are mixed with non-autoclavable chemicals must be disposed of through Chematix. Gloves must not be disposed of in the regular garbage. Gloves used for biohazardous work must be decontaminated prior to disposal. Gloves can be accumulated with solid biohazardous waste.

Forms, Links and Manuals

Laboratory Safety Checklist https://cloudfront.ualberta.ca/-/media/ualberta/vice-president-finance/environment-health-saftey/documents/laboratory-safety-checklist.docx

Safety Data Sheetshttps://www.sigmaaldrich.com/safety-center.html

Laboratory and Chemical Safety Training- https://www.ualberta.ca/biological-sciences/safety/chemical-safety/index.html

Visitor registration and waiver of liability- https://cloudfront.ualberta.ca/-/media/research/academic-visitor-office/registration/liabilitywaiverfillable.pdf (unable to find a replacement link)

University of Alberta waiver request form- https://docs.google.com/forms/d/e/1FAIpQLScs32mDlK3OThxVzY30L112_D2HOio5o1b-iNdWuhAxquGAQw/viewform

Waiver and Informed Consent forms- https://www.ualberta.ca/vice-president-finance/media-library/ualberta/vice-president-finance/risk-management-services/ira/complete-set-of-waiver-guidelines.pdf

Chematix- https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/lab-safety-and-management/set-up-a-lab/dispose-of-hazardous-waste/index.html

Reporting an injury or incident- https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/report-an-incident/index.html

PPE Checklist
https://docs.google.com/document/d/1Ea5PThK93OOaORsg6LObCs6dgt2R2fodIItoqPPvcJ8/edit

Equipment Decontamination Form - https://www.ualberta.ca/vice-president-finance/media-library/ualberta/vice-president-finance/environment-health-saftey/documents/equipment-decontamination-form.docx

Lab close out or renovation- https://www.ualberta.ca/vice-president-finance/environment-health-and-safety/lab-safety-and-management/close-out-or-renovate-a-lab.html

Appendix 1

Potential Health Hazards of Laboratory Chemicals

Irritants - cause inflammation (redness and swelling) of the skin or mucous membranes following immediate, prolonged, or repeated direct contact. Effects can be severe, but are generally reversible.
Corrosives – generally cause visible damage (severe irritant) to skin, eyes, or the mucous membranes of the respiratory or gastrointestinal tract on contact. Can result in severe burns or blistering of the skin or impaired vision or blindness.
Asphyxiants – take oxygen away from the body, a tissue or a cell, causing injury or death due to suffocation.

- Simple (physical) asphyxiants - gases (CO, CO2, He, N and Ar) that displace oxygen.
- Chemical asphyxiants – reduce the body's ability to absorb, transport, or utilize inhaled oxygen. CO decreases blood's ability to carry oxygen to cells, while hydrogen sulphide and hydrogen cyanide interfere with the cell's ability to use oxygen.

Primary Anesthetics – depresses central nervous system activity e.g. diethyl ether, hexane, etc. Signs and symptoms include headache, nausea, dizziness, and mental confusion, lack of muscle coordination, unconsciousness, and death.
Systemic Poisons – cause damage to targeted organs or tissues of the body including the lungs, liver, kidneys, and the nervous system.
Carcinogens - cause cancer or increase the risk for development of cancer.
Reproductive Toxins – mutagens (interfere with replication of genetic material, causing mutations in exposed cells) and teratogens (interfere with normal embryonic development and can lead to miscarriage or congenital defects).
Sensitizers - cause an allergic reaction in normal tissue after repeated exposure to the chemical.

- Skin – severe reaction can include redness, itching, swelling or hives.
- Respiratory – severe asthmatic response, including coughing, wheezing, shortness of breath, chest pain, difficulty breathing and potentially, death.

Factors to Consider When Assessing the Toxic Potential of Laboratory Chemicals

Route of exposure – main routes of exposure through which chemicals can come into contact with or enter the body. These include:

- Chemicals absorbed most rapidly by inhalation, resulting in higher potential doses and a greater likelihood of injury
- Chemicals absorbed more slowly through the skin and thus, for a similar exposure (quantity and time), less chemical tends to enter the body than for respiratory or gastrointestinal exposures
- Ingestion exposures are more likely to cause harm than dermal exposures, but are less likely, overall, because skin is more exposed to chemicals
- Inhalation - chemicals that become airborne can be inhaled, including:
    - Gases and vapors (the gaseous form of substances normally liquid or solid at room temperature) can reach the alveoli of the lung and readily enter the body. There is a high risk of acute toxicity because they can enter the blood directly.
    - Aerosols are solid or liquid particles dispersed in a gaseous medium. Particle size determines the depth to which aerosols are deposited in the respiratory system; the smaller the particle size, the deeper into the lungs they can be deposited. Aerosols include dusts, fumes, smoke, fogs or mists and smog.

- Skin Contact – cause direct effects at the point of contact or can be absorbed through the skin and cause systemic effects. More than 150 chemicals can be absorbed through the skin. Bruises, cuts and abrasions allow a chemical to be absorbed more readily
- Ingestion – the least common route of exposure, wherein the primary mechanisms are eating with contaminated hands or consuming contaminated food or drink.
- Eye Contact – through airborne dusts, mists, fumes, gases, or vapors or through splashing of liquids.
- Injection - by way of needles or broken glass that deposit chemicals through punctures in the skin.

Length of Exposure (Duration/Frequency/Timing)

- Acute exposure (short term exposure) – Usually a single exposure or repeated exposures over a short period of time (minutes, hours or days). Effect usually has a rapid onset and may include irritation, corrosion, central nervous system depression, or asphyxiation. Health effects are generally reversible.
- Chronic exposure (long-term exposure) – Continuous exposure or repeated exposures occurring over an extended period of time (months or years). Symptoms either take a long time to manifest themselves, or they manifest themselves rapidly and are long lasting. Health effects are often long lasting or permanent/irreversible (e.g. nerve damage, tumors, etc.).
- Chronic exposure is of greater concern when the chemical is able to accumulate in the body. The cumulative toxic effect, whether it is the same chemical or chemicals with similar target organs, is dependent on solubility (especially lipid solubility), metabolism and excretion.

Local vs. Systemic effect

- Highly reactive chemicals are more likely to have local effects, whereas those that are less reactive are more likely to be absorbed and accumulate in target organs causing systemic health effects. Some chemicals have both local and systemic effects.
- Interactive effects with other chemicals – toxic potential of a chemical can be influenced by the presence, or previous exposure (accumulation), of other chemicals depending on the interaction of the chemicals with respect to health effects.
- Independent effect – chemicals have toxicities independent of each other.
- Additive effect - the total effect is the sum of the two independent effects.
- Synergistic effect - the effect of two chemicals is greater than the expected additive effect.
- Potentiating effect (a form of synergistic effect) - one of the compounds is not toxic in itself but enhances the effect of another compound.
- Antagonistic effect - one compound opposes the effect of another
- Individual susceptibilities – factors associated with individuals that modulate their response to a particular chemical. The toxic potential of a given chemical for an individual is influenced by:
    - Genetics – most particularly related to the complement of enzymes available for an individual to metabolize or detoxify absorbed chemicals.
    - Gender
    - Age - in general, infants (undeveloped systems) and old people (poor immune system) are more sensitive to toxic chemicals
    - Pregnancy
    - Health condition
    - Previous exposures - allergies or sensitivities

Physical/chemical properties of a chemical

- Solids:
    - Generally little risk, but can get adverse effects through contact (irritant or corrosive).
    - Smaller particles can become airborne (dusts) and can persist in the respiratory tract
    - May be solubilized by moisture on the skin or in the digestive tract leading to absorption
- Liquids:
    - Fluidity gives mobility and problems with containment
    - More readily converted to vapors or aerosols and present a greater risk for inhalation
    - Have the potential to dissolve other chemicals and enhance toxic effects.
- Gases:
    - Can have physical (asphyxiant) and chemical adverse effects.
    - Solubility - influences reactivity, route of entry, metabolism, excretion and accumulation.
    - Purity - impurities can have toxic effects alone or through interaction with the chemical.
    - Boiling or vaporization point – influences volatility and flammability

Appendix 2:
An example of Hazard Assessment and Control report

UNIVERSITY OF ALBERTA

Department of Agricultural, Food and Nutritional Science
Faculty of Agricultural, Life & Environmental Sciences

Hazard Assessment and Control Report

Title or description of Procedure, Equipment or Process	Department	Completed by	Date
Determination of Acid Detergent Fiber (ADF) – ANKOM Fiber Analyzer	Proximate Analysis Dept. AFNS, University of Alberta, Ag/For Centre, Edmonton	Kelvin Lien	Nov 14, 2013

Chemical	WHMIS Class	Chemical Hazard (HMIS) Ratings				Hazard Control
		Health 0 - 4	Flammability 0 - 4	Reactivity 0 - 4	Potential Dose*	
Cetyltrimethylammonium bromide (CTAB)	D-2B Toxic	2 Irritant	1	0	Med	Work in a fume hood to control airborne concentrations. Ensure access to eyewash and safety showers. Ensure familiarity with MSDS and emergency procedures. Gloves, splash goggles, and dust mask.
Sulfuric Acid	D-1A Very Toxic E Corrosive	3	0	2	Med	Work in fume hoods when possible to control vapors. Ensure availability of eyewash station and safety shower. Ensure familiarity with MSDS and emergency procedures. PPE – gloves, splash goggles and acid resistant apron.
Acetone	B-2 Flammable D-2B Toxic	2	3	0	High	Work in fume hoods when possible to control vapors. Ensure availability of eyewash station and safety shower. Ensure familiarity with MSDS and emergency procedures. PPE – gloves, eye protection

Task or Task Sequential Step	Environmental Factor, Equipment, Material, Harmful Substance, etc	Potential Hazard	Hazard Control
General	Glassware	- Cuts, lacerations	Inspect all glassware for chips and cracks before use Dispose of clean damaged glass in approved container.

7.3.1.2	Adding concentrated sulfuric acid to water	Splashing (skin/eye contact) Process is exothermic and burns can result	Strong recommendation to purchase prepared solution from ANKOM (avoid using concentrated chemicals) Add acid very slowly to water - large volume prohibits cooling of solution in an ice-bath so extreme care must be taken. PPE – gloves, splash goggles, acid resistant apron
7.3.1.3	Working with cetyltri-methylammonium bromide (CTAB)	See above for chemical health hazards Large quantity increases risk of dust and exposure	PPE same as above – gloves, splash goggles, acid resistant apron – plus a dust mask to prevent inhalation. If possible work in a fume hood.

7.3.1.4	Stir with overhead stirrer	Stirrer could drop or run out of control causing the carboy to break (large spill) Stirrer could cause splashing Electric – shock hazard	Inspect stirrer and cords prior to use – do not use - report damage Ensure that stirrer is properly secured and stable Avoid contact with the stirring rod Never leave stirrer unattended
9.1	Increased airborne dust from powdered samples	- Potential for inhalation of dust, potential toxic effects from samples	Hazard is dependent on nature and amount of sample – protection is sample specific and should be covered by separate hazard assessment. For work with powdered samples, dust masks are recommended Requirement for gloves based on the nature of the sample
9.1.5	Heat sealer	Shock and burns from exposed electric components Burns from heated surfaces	Inspect the instrument and cords for damage Avoid working in areas with obvious moisture and fuel sources (ignition risk) Instrument has exposed heated and electrical surfaces, care must be taken to avoid contact
9.2.2	Fiber analyzer vessel	Shock – electrical equipment Pinches – closing the lid Burns – operation requires heating the vessel	Inspect vessel and cords for damage – do not use - report damage Training for proper closure and operation Warning not to touch vessel while in operation
9.3.1	Opening hot vessel lid	Burns – hot liquid (contents under pressure) and steam Chemical burns, chemical exposure	- WARNING – do not open vessel lid – vessel must be drained through the exhaust prior to opening – see SOP.

9.3.2/9.4.1	Exhausting vessel contents	Burns from hot liquid and steam Inhalation/contact exposure to hot chemicals	Inspect exhaust hose for damage (replace if necessary) Ensure that hose is securely securely attached to the vessel Ensure hose and receiving vessel are secured. Avoid inhalation of steam
9.4.1	Hot water	- Burns, scalding	- Wear insulated gloves when transferring to the vessel
9.5.5	Drying oven	Burns (110º C) Potential fire with acetone in oven	Acetone must be dried completely from the samples, in the fume hood, to order to avoid contact of acetone with heating elements Heat resistant gloves for removing samples from the oven

Name of Reviewing Supervisor	Signature of Reviewing Supervisor	Date

HMIS: Health Hazard Rating Chart
Chronic Hazard - Chronic(long-term) health effects may result repeated overexposure. 0 = Minimal Hazard - No significant risk to health
1 = Slight Hazard - Irritation or minor reversible injury possible 2 = Moderate Hazard - Temporary or minor injury may occur.
3 = Serious Hazard - Major injury likely unless prompt action is taken and medical treatment is given.
4 = Severe Hazard - Life-threatening, major or permanent damage may result from single or repeated overexposures.

HMIS: Flammability Hazard Rating Chart
0 = Minimal Hazard - Materials that will not burn.
1 = Slight Hazard - Materials that must be preheated before ignition will occur. Includes liquids, solids and semi solids having a flash point above 200° F. (Class IIIB)
2 = Moderate Hazard - Materials which must be moderately heated or exposed to high ambient temperatures before ignition will occur. Includes liquids having a flash point at or above 100° F but below 200° F. (Classes II & IIIA)
3 = Serious Hazard - Materials capable of ignition under almost all normal temperature conditions. Includes flammable liquids with flash points below 73° F and boiling points above 100° F as well as liquids with flash points between 73° F and 100° F. (Classes IB & IC)
4 = Severe Hazard - Flammable gases, or very volatile flammable liquids with flash points below 73° F, and boiling points below 100° F. Materials may ignite spontaneously with air. (Class IA)

HMIS: Physical Hazard Rating Chart
0 = Minimal Hazard - Materials that are normally stable, under fire conditions and will not react to water, polymerize, decompose, condense or self react.
1 = Slight Hazard - Materials that are normally stable but can become unstable at high
temperature and pressures. Materials may react non-violently with water or undergo hazardous polymerization in the absence of inhibitors.
2 = Moderate Hazard - Materials that are unstable and may undergo violent chemical change at normal temperature and pressure with low risk for explosion. Materials may react violently with water or form peroxides upon exposure to air.
3 = Serious Hazard - Materials that may form explosive mixtures with water are capable of
detonation or explosive reaction in the presence of a strong initiating source or undergo chemical change at normal temperature and pressure with moderate risk of explosion.
4 = Severe Hazard - Materials that are readily, capable of water reaction, detonation or explosive decomposition at normal temperatures and pressures.

Potential Dose Rating
Exposure (Dose) based on the amount of chemical one is working with (based on U of A HSE Spill Response Guidelines):
High = High Exposure – For Stock Chemicals/Solutions: Flammable liquids more than 500ml; all other Chemicals more than 1 litre liquid or 500 grams solid (Spill is considered by U of A HSE to be an Emergency).
Med =Moderate Exposure - Stock Chemicals/Solutions: Flammable liquids more than 100ml; all other chemicals more than 100 milllitre liquid or 50 grams solid
Low = Low Exposure - Stock Chemicals/Solutions: Flammable liquids less than 100ml; all other chemicals less than 100 millilitre liquid or 50 grams solid

Appendix 3 COMMON CHEMICAL INCOMPATIBILITIES

The following list is a quick reference of incompatibilities of many chemicals commonly encountered in the laboratory. It is not a comprehensive list of all possible combinations and chemicals. For details on any chemical, check the MSDS.

Chemical	Incompatibilities for Chemical Storage
Acetic Acid	Aldehydes, bases, carbonates, chromic acid, ethylene glycol, hydroxides, metals, oxidizers, perchloric acid, peroxides, permanganates, phosphates, xylene, nitric acid
Acetic Anhydride	Acids, alcohols, bases, finely divided metals, oxidizers, reducing agents
Acetone	Inorganic acids, amines, hydrogen peroxide, oxidizers, plastics
Acetylene	Copper metal, halogens, mercury, potassium, silver, oxidizers
Alkalis	Acids, carbon dioxide, chlorinated hydrocarbons, chromium, flammable liquids, mercury, oxidizers, salt, Sulphur, water
Ammonium Nitrate	Acids, alkalis, chlorates, fine organic powders, metals, nitrates, oxidizers, sulfur
Aniline	Inorganic acids, dibenzoyl peroxide, hydrogen peroxide, oxidizers
Azides	Acids, heavy metals, oxidizers
Bromine	Acetaldehyde, acetylene, alcohols, alkalis, amines, benzene, butadiene, butane and other petroleum gases, ethylene, fluorine, hydrogen, ketones, finely divided metals, sodium carbide, sulfur, turpentine
Calcium Oxide	Acids, ethanol, fluorine
Carbon (activated)	Alkalis, oxidizers, calcium hypochlorite, halogens
Carbon Tetrachloride	Benzoyl peroxides, ethylene, fluorine, oxygen, silanes
Chlorates	Acids, ammonium salts, carbon, metal powders, sulfur, finely divided combustibles and organics
Chromic Acid	Acetic acid, acetone, alcohols, alkalis, ammonia, bases, camphor, flammable liquids, glycerin, turpentine
Chlorine	Acetylene, ammonia, benzene, butadiene, ethylene and other petroleum gases, hydrazine, hydrogen, hydrogen peroxide, iodine, sodium hydroxide, turpentine, other petroleum components, finely divided metals
Chlorine Dioxide	Ammonia, hydrogen, hydrogen sulfide, mercury, methane, phosphine, phosphorous, potassium hydroxide
Copper	Acetylene, calcium, hydrogen peroxide, oxidizers
Cyanides	Acids, alkalis, strong bases
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Ammonia, halocarbons, halogens, ketones, metals, organic acids, hydrocarbons, other combustible material
Hydrazine	Inorganic acids, hydrogen peroxides, oxidizers
Hydrocarbons	Acids, bases, oxidizers
Hydrochloric Acid	Alkali metals, amines, bases, copper, copper alloys, aluminum, moisture
Hydrofluoric Acid	Ammonia, glass, organics, sodium

Hydrogen Peroxide	Acetylaldehyde, acetic acid, acetone, alcohols, aniline, carboxylic acids, flammable liquids and combustible material, metals and their salts, nitric acid, nitromethane, organics, phosphorous, sodium, sulfuric acid
Hydrogen Sulfide	Acetylaldehyde, oxidizers, sodium
Hypochlorites	Acids, activated carbon
Iodine	Acetylaldehyde, acetylene, ammonia, hydrogen, sodium
Mercury	Acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizers
Nitrates	Sulfuric acid, other acids, nitrites
Nitric Acid (Conc.)	Acetic acid, acetonitrile, amines, ammonia, aniline, bases, benzene, brass, chromic acid, copper, cumene, flammable liquids and gases, formic acid, heavy metals, hydrogen sulfide, ketones, organic substances, sodium, toluene
Nitrites	Acids, nitrates
Nitroparaffins	Amines, inorganic bases
Oxalic Acid	Mercury, oxidizers, silver, sodium chlorite
Oxygen	Acetylaldehyde, alkalis, ammonia, carbon monoxide, ethers, flammable gases, liquids & solids, hydrocarbons, phosphorous
Perchloric Acid	Acetic acid, acetic anhydride, alcohols, aniline, bismuth and bismuth alloys, combustible materials, dehydrating agents, ethyl benzene, hydroiodic acid, hydrochloic acid, grease, iodides, ketones, other organic materials, oxidizers, pyridine
Peroxides, Organic	Acids (inorganic, organic)
Phosphorous	Air, alkalis, oxygen, reducing agents
Potassium	Acetylene, acids, alcohols, carbon dioxide, carbon tetrachloride, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium Chlorate	Acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic substances, sugars
Potassium Perchlorate	Acids, alcohols, combustible material, fluorine, hydrazine, metals, organic materials, reducing agents
Potassium Permanganate	Benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, ammonia, ammonium compounds, fulminic acid, oxalic acid, oxidizers, ozonides, peroxyformic acid
Sodium	Acids, carbon tetrachloride, carbon monoxide, hydrazines, metals, oxidizers, water
Sodium Nitrate	Acetic anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium Nitrite	Ammonium nitrate and ammonium salts
Sodium peroxide	Acetic acid, acetic anhydride, benzene, benzaldehyde, carbon disulfide, ethyl acetate, furfural, glycerin, hydrogen sulfide, metals, methyl acetate, peroxyformic acid, phosphorous
Sulfides	Acids
Sulfuric Acid	Flammable and combustible liquids, potassium chlorate, potassium perchlorate, potassium permanganate, like compounds of sodium and lithium
Tellurides	Reducing agents