LABORATORY SAFETY

Merle J Heineke
Director, Research Laboratories
Occupational Safety and Health Act of 1970

- The purpose is to assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; but providing for research, information, education, and training in the field of occupational safety and health.

- More than 500,000 workers are employed in laboratories in the US. The laboratory environment can be a hazardous place to work. Laboratory workers are exposed to numerous potential hazards including chemical, biological, physical, and radioactive hazards as well as musculoskeletal stresses. Over the years, OSHA has promulgated rules and published guidance to make laboratories increasingly safe for personnel.
Principal OSHA Standards

- The Occupational Exposure to Hazardous Chemicals in Laboratories standard (29 CFR 1910.1450)
- The Bloodborne Pathogens standard (29 CFR 1910.1030)
- The Personal Protective Equipment (PPE) standard (29 CFR 1910.132)
- The Eye and Face Protection standard (29 CFR 1910.133)
- The Hand Protection standard (29 CFR 1910.138)
- The Control of Hazardous Energy standard (29 CFR 1910.147)
Hierarchy of Controls

- Prioritizes intervention strategies based on the premise that the best way to control a hazard is to systematically remove it from the workplace rather than relying on workers to reduce their exposure

  - Elimination
  - Substitution
  - Engineering controls
  - Administrative controls
  - Personal Protective Equipment
The Laboratory Standard

- Categorizes the types of hazards:
  - Chemical
  - Biological
  - Physical
  - Safety
  - Other Hazards
Chemical Hazards

- Hazardous chemicals present physical and/or health threats to workers in clinical, industrial and academic laboratories. Laboratory chemicals include cancer-causing agents, toxins, as well as agents that act on the blood system or damage the lungs, skin, eyes, or mucous membranes.

- The Laboratory standard consists of 5 major elements:
  - Hazard identification/SDS
  - Chemical Hygiene Plan (CHP)
  - Information and training
  - Exposure monitoring
  - Medical consultation and examinations
Biological Hazards

- Many laboratory workers encounter daily exposure to biological hazards. These hazards are present in various sources throughout the laboratory such as blood and body fluids, culture specimens, body tissue and cadavers and laboratory animals as well as other workers.

- The Bloodborne Pathogen standard is designed to protect workers from the health hazards of exposure to bloodborne pathogens.
  - Select safer needle devices; do not recap needles; place needles in a Sharps container
  - Prohibit mouth pipetting
  - Prohibit eating, drinking in the laboratory
  - Provide appropriate PPE
  - Provide effective engineering and work practice controls
  - Provide facilities for hand washing and emergency shower/eyewash station
  - Provide appropriate signage
## CDC Summary of Recommended Biosafety Levels for Infectious Agents

<table>
<thead>
<tr>
<th>Biosafety Level</th>
<th>Agent Characteristics</th>
<th>Practices</th>
<th>Safety Equipment</th>
<th>Facilities (secondary barriers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSL-1</td>
<td>Not known to consistently cause disease in healthy adults</td>
<td>Standard microbiological Practices</td>
<td>None</td>
<td>Open bench top sink</td>
</tr>
<tr>
<td>BSL-2</td>
<td>Associated with human disease, hazard from percutaneous injury, ingestion, mucous membrane exposure</td>
<td>Standard microbiological Practices Limited access Biohazard warning signs Sharps precautions Biosafety manual defining any needed waste decontamination or medical surveillance policies.</td>
<td>Class I or II biosafety cabinets (BSCs) or other containment devices used for all agents that cause splashes or aerosols of infectious materials Laboratory coats and gloves Face protection as needed</td>
<td>Open bench top sink Autoclave</td>
</tr>
<tr>
<td>BSL-3</td>
<td>Indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences All BSI+2 practices Controlled access Decontamination of all waste Decontamination of laboratory clothing before laundering Baseline serum</td>
<td>All BSI+3 practices Clothing change before entering Shower on exit All material decontaminated on exit from facility</td>
<td>Class I or II BSCs or other physical containment devices used for all open manipulations of agents Protective lab clothing and gloves Respiratory protection as needed</td>
<td>Open bench top sink Autoclave Physical separation from access corridors Self-closing, double door access Exhaust air not recirculated Negative airflow in laboratory</td>
</tr>
<tr>
<td>BSL-4</td>
<td>Dangerous/exotic agents which pose high risk of life-threatening disease; aerosol transmitted lab infections; or related agents with unknown risk of transmission</td>
<td>All BSL-3 practices Clothing change before entering Shower on exit All material decontaminated on exit from facility</td>
<td>All procedures conducted in Class III BSCs, or Class I or II BSCs in combination with full-body, air-supplied, positive pressure personnel suit.</td>
<td>BSL-3 plus: Separate building or isolated zone Dedicated supply and exhaust, vacuum, and decontamination systems Other requirements outlined in the text</td>
</tr>
</tbody>
</table>
Physical Hazards

- Ergonomic Hazards – includes repetitive motion injuries
- Ionizing Radiation – WSU requires all persons who work with ionizing radiation to complete the training course found at https://rso.wsu.edu/
- Non-ionizing Radiation – a series of energy waves composed of oscillating electric and magnetic fields traveling at the speed of light; includes the spectrum of ultraviolet (UV), visible light infrared (IR), microwave (MW), radio frequency (RF), and extremely low frequency (ELF). Eye protection is required when working with UV lights.
- Noise – can be produced by laboratory equipment (fume hoods, biosafety cabinets, incubators, centrifuges, compressors). Protection is required if workers are exposed to a time-weighted average of $\geq 85$ dBA over an 8 hour work shift.
Safety Hazards

- Autoclaves and Sterilizers – potential for burns or cuts; wear insulated gloves
- Centrifuges – potential for injuring users if not operated properly
- Compressed Gases – can be toxic, flammable, oxidizing, corrosive or inert; leakage of the gas can be hazardous
- Cryogens and Dry Ice – dangers include cold contact burns, asphyxiation, explosion
- Electrical – dangers include electric shock, electrocution, damaged electrical cords, faulty electrical equipment, damaged receptacles, fires and explosions. Do not overload circuits. Do not use gang plugs.
- Lockout/Tagout – prevents the use of equipment that is not working properly
- Trips, Slips and Fall – steps should be taken to maintain an uncluttered, clean and dry work area
Safety Hazards - Fire

- Fire – most common hazard in a laboratory. Laboratories that use solvents have the potential for flash fires, explosion, rapid spread of fires and high toxicity of products of combustion

- Steps to take include:
  - Have an emergency plan
  - Minimize flammable materials; store in a flammable cabinet
  - Keep area clean, uncluttered
  - Keep barriers in place (shields, hood sashes, lab doors)
  - Wear proper clothing and PPE (flame resistant lab coats)
  - Shut door when you evacuate
  - Limit open flame use to within fume hood and only when attended; substitute for open flame when possible (electric Bunsen burner)
  - All employees should complete fire emergency training
Important Websites

- Environmental Health and Safety: https://spokane.wsu.edu/facilities/
- Research CORES: https://spokane.wsu.edu/research/core-facilities/
- Lab Safety: https://spokane.wsu.edu/research/lab-safety/
- SDS Forms: https://msdsmanagement.msdsonline.com/40718b1d-e2b8-4eb2-a3a8-13c45df9c974/ebinder/?nas=True
- IACUC: https://iacuc.wsu.edu/
- Radiation Training: https://rso.wsu.edu/

- Every person working in a laboratory should take the time to familiarize themselves with these websites and refer to them frequently.
The WSU Laboratory Safety Manual provides guidance for all laboratories on campus. The detailed document can be found at: https://ehs.wsu.edu/labsafety/LabSafetyManual.html. A condensed version will be posted at https://spokane.wsu.edu/research/lab-safety/ later this week.

Basic Rules and Procedures

- The Principle Investigator (PI) or laboratory supervisor is responsible for the compliance of the laboratory and staff with the WSU Laboratory Safety Manual.
- Do not work alone in the laboratory if working with hazardous agents.
- Reagents should be combined in an appropriate order to minimize violent chemical reaction.
- Reaction apparatus should be positioned and clamped in order to permit manipulation without the need to move the apparatus until the entire reaction is completed.
WSU Laboratory Safety Manual

- Chemical Procurement, Storage & Distribution
  - Develop and maintain an inventory control system
  - Designate a person who is responsible for materials brought into the laboratory

- Exposure Monitoring
  - If a worker is working with a hazardous agent outside a fume hood and displays symptoms
  - If 2 or more persons in the same area display similar symptoms

- Medical Surveillance
  - This section is consistent with the OSHA regulations. Medical care is provided at no expense to the researcher.
WSU Laboratory Safety Manual

- Housekeeping
  - Do not use stairways, hallways, or mechanical spaces (electrical panels) as storage areas
  - Waste should be deposited in appropriate receptacles
  - Generators of waste are responsible for the proper disposal of the waste
  - The waste collection program at Spokane is:
    - White containers/clear autoclave bags – autoclavable waste
    - Red containers/red bags – biohazardous waste
    - Orange containers/orange bags – pathological waste
    - Yellow containers/yellow bags – radioactive waste
    - Plastic (blue) containers/tear resistant bags – disposable glassware
    - Purple waste containers – solids exposed to chemical hazards
    - Sharps containers – designated container
Personal Protective Equipment

- Employees must be trained in the proper use of PPE; training must be documented.
- Long pants should be worn at all times
- Open-toed shoes or sandals should not be worn in the laboratory
- Jewelry (rings, bracelets, earrings) should be removed
- Select gloves based on the material being handled; double layering is recommended when very hazardous chemicals are handled
- Do not wear gloves when moving through the lab; do not touch common surfaces with gloved hands
- Remove gloves properly
- Lab coats should be cleaned regularly; notify the cleaning service if contaminated with a hazardous agent
WSU Laboratory Safety Manual

- Respirators (N95) – requires medical clearance and annual fit testing
- Recordkeeping – the CHP must be updated as new chemicals are received and reviewed by the PI or laboratory supervisor annually
- Signage and Labeling – Regulations require that ALL work areas and reagents are to be clearly labeled. This prevents confusion about what is safe and what is hazardous. Non-laboratory staff are entitled to the same level of safety as the research staff.
- Secondary Labelling – Reagents moved to a secondary label must be identified with the name of the reagent, the signal word (Nonhazardous, Warning, Danger) and the appropriate pictogram
- If mixing reagents, check the SDS to ensure compatibility. Non-compatible reagents could produce a hazardous gas.
- Waste receptacles must be properly labeled
- Notify Chad Trent when the waste receptacle is ready for pick-up. The form and label templates can be found at https://spokane.wsu.edu/facilities/environmental-health-and-safety/forms/
Signage

Physical Hazards
- Flammable
- Compressed Gas
- Oxidizing
- Corrosive
- Explosive

Health Hazards
- Health Hazard
- Corrosive
- Skin Irritant
- Toxic

Reference Tools

Environmental Hazards

http://www.osha.gov/dsl/hazcom/ghs.html

Environmental Hazard
Chemical Spill Clean-Up and Reporting – employees must be trained to safely clean up chemical spills. If not trained, call 911 and notify Chad Trent.

Training, Information, and Factsheets – The PI or laboratory supervisor is responsible for providing the employee with training and information.

Laboratory Inspections – The Health & Safety group perform annual laboratory inspections, work with the individual labs to maintain required documents and provide training as necessary. The PI or laboratory supervisor should also routinely inspect the lab. Washington State Department of Safety & Health and the Fire Department also inspect laboratories.

Safety Data Sheets – SDS sheets must be readily accessible to employees at all time; on-line information is available at https://msdsmanagement.msdsonline.com
WSU Laboratory Safety Manual

- Carcinogens in Laboratories
  - Select Carcinogens – follow the policies and procedures in the Laboratory Safety Manual and Chemical Hygiene Plan
  - Listed Carcinogens – establish a designated work area with restricted access and negative air pressure, protect work surfaces and vacuum systems, collect contaminated waste in impervious containers, perform a hazard assessment, remove and leave PPE in the regulated area, wash hands, forearms, face and neck upon exiting, maintain inventory of the carcinogen
  - Specific Carcinogen – contact EH&S prior to ordering the agent

- A list of the carcinogens can be found in the Laboratory Safety Manual
Chemical Hygiene Plan

- Purpose – WSU has a commitment to create, maintain, and enhance a safe and healthful environment for all individuals associated with the university. The purpose of the Chemical Hygiene Plan (CHP) is to establish policies and procedures for a specific laboratory.

- The WSU template will be posted later this week at https://spokane.wsu.edu/research/lab-safety/
Chemical Hygiene Plan

- Implementation of the Chemical Hygiene Plan
  - Standard Operating Procedures (SOPs) for the hazardous chemicals used
  - Designated area provisions
  - Description of or provisions for fume hoods and other protective equipment
  - Provisions for employee information, training, and medical monitoring and examination
  - Evaluation criteria used to reduce exposure
  - Prior approval for special laboratory projects
Chemical Hygiene Plan

- Responsibilities
  - The University Health and Safety Committee – provides advice and support on matters of policy and procedures relating to health, safety, and security
  - Environmental Health & Safety – promotes programs that are needed for compliance with safety and health regulations and for the protection of personnel
  - Department Chairperson or Director – reviews the control methods used by the PI or laboratory supervisor and ensures that required authorizations are on file
  - Principle Investigator, Faculty or Laboratory Supervisor – enforces University laboratory safety rules, lab specific procedures, trains employees, correct improper work practices, identifies defective environmental conditions, maintains the Chemical Hygiene Plan
  - Employee or Student – knows and complies with safety guidelines and policies, reports unsafe conditions to the PI or laboratory supervisor, utilizes safety equipment and PPE properly
Examples from Industry
Examples from Academia
Common Laboratory Equipment

- Your research is only as good as your equipment
- Check every day for:
  - Cleanliness of the equipment
  - Is the equipment at the proper temperature
  - Is the equipment certified
  - Does the balance weigh accurately
  - Does the centrifuge spin as indicated
Equipment - Biosafety Cabinets

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<th>Classification</th>
<th>Biosafety Level</th>
<th>Application</th>
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<tr>
<td>Class I</td>
<td>1, 2, 3</td>
<td>Low to moderate risk biological agents</td>
</tr>
<tr>
<td>Class II</td>
<td>1, 2, 3</td>
<td>Low to moderate risk biological agents</td>
</tr>
<tr>
<td>Class III</td>
<td>4</td>
<td>High risk biological agents</td>
</tr>
</tbody>
</table>

- Must be certified annually or if moved
- Disinfect the work surface before and after each use
- Always wear gloves and a lab coat
- Use optimal sash height
- Do not block air intake to the front grille
- Keep your movements slow and deliberate
- The UV light should not work when the sash is up; the UV light should be either left on or turned on at least 20 minutes before use.
- Return the sash to the down position when done working
Airflow Characteristics of Class II BSC
Equipment – Fume Hood

- Must be certified annually
- Before using, make sure the work area is clean and uncluttered
- Always wear gloves and a lab coat
- Check the airflow indicator; average velocity is between 100-150 feet per minute
- Elevate large equipment 1-2 inches above work surface to maintain airflow
- Work at least 6 inches into the hood
- Keep your movements slow and deliberate
- Keep the sash at 18 inches or less
- Return the sash to the down position when done working
- Excess storage of chemicals.
- Exhaust slots blocked.
- Containers stored within six inches of face of hood.
Example of a fume hood that is set up correctly.

- **Exhaust slot**
- **Hood set at 18 inches.**
- **Minimum storage along the side wall.**
Equipment - Autoclave

- Uses a combination of steam, heat, and pressure to sterilize
- Most significant hazard is the risk of steam burns; wear heat resistant gloves
- Check that the drain is clean and free of debris before each cycle
- Use an autoclavable bin to capture all liquids
- Position the packages so that they do not touch the sides
- After closing the door, check that the screen reads “Jacket On”
- Select the appropriate cycle and time
- If the autoclave is used to sterilize supplies for animal surgery, the unit must be certified. See IACUC SOP #5. Currently the only certified units are in the vivarium.
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<th>Basic Cycles</th>
<th>Description</th>
<th>Typical Application or Load Type</th>
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<tr>
<td>Gravity</td>
<td>The most basic sterilization cycle. Steam displaces air in the chamber by gravity (i.e. without mechanical assistance) through a drain port.</td>
<td>Glassware, unwrapped goods, waste, utensils, redbags.</td>
</tr>
<tr>
<td>Pre-vacuum and/or Post-Vacuum</td>
<td>Air is mechanically removed from the chamber and load through a series of vacuum and pressure pulsos. This allows the steam to penetrate porous areas of the load that couldn’t otherwise be reached with simple gravity displacement.</td>
<td>Wrapped goods, packs, animal cage bedding, cages, porous materials, redbags.</td>
</tr>
<tr>
<td>Liquids</td>
<td>A gravity cycle with a slower exhaust rate to minimize boil-over.</td>
<td>Media, LB broth, water, etc.</td>
</tr>
<tr>
<td>Immediate Use/Flash (Healthcare sterilizers only)</td>
<td>High temperature cycle (over 270°F) for a shorter period of time.</td>
<td>Unwrapped goods</td>
</tr>
</tbody>
</table>
Equipment - -80° Freezer

- Check the temperature of the freezer daily
- Limit the length of time the door is open; if open for more than a brief period, the freezer will pull a vacuum that prevents the door from opening until it returns to temperature
- Wear the appropriate gloves to prevent frostbite
- The freezers are alarmed. Facilities must be notified (work request) in advance if the freezer is to be defrosted or moved.

Care of the freezer:
- Clean the condenser filters and door gasket every 2-3 months
- Clean the condenser every 6 months
- Check the door panel alarm battery every 12 months; battery only supports the door panel, not the entire freezer
- Defrost the freezer at least once a year; use a plastic scraper to remove frost buildup; be careful to not puncture or tear the door gasket
Equipment - Centrifuge

- Centrifugal force separates sample components by density
- Keeping the centrifuge clean is critical to prevent cross contamination; wipe with a disinfectant before and after each use
- Most important safety procedure is to balance the vials within the rotor; unbalanced rotors cause extreme vibrations and pose an “explosion” hazard
- May also generate aerosols; if working with infectious material, samples must be properly enclosed so that aerosols do not escape
- When finished running, do not open sample tubes outside the confines of a biosafety cabinet
Water Quality

- Domestic water – used for indoor and outdoor household purposes
- Distilled water - boiled into vapor and condensed back into liquid in a separate container. Impurities in the original water that do not boil below or at the boiling point of water remain in the original container
- Deionized water – water that does through the process of removing ions from it; water is passed through a deionized reaction to remove dissolved particles
- Reverse Osmosis water – filters most known water impurities found in domestic water
- Purified water – defined by the levels (or lack thereof) of any impurities found in the water. The impurity load of dissolved solids in purified water cannot exceed 10 parts-per-million. The water that meets this threshold is inherently of a higher purity than domestic or filtered water
- Non-Potable water – this water is not suitable for drinking. Laboratory sinks should have a sign indicating that the water is non-potable. Ice from the ice machines is also unsuitable for human consumption.
Gas Cylinders
Dry Ice Shipments

- Persons training to ship dry ice are: Ze Liu, Megan Chastain, Merle Heineke
- Submit a Shipping Request Form 24 hours in advance: https://spokane.wsu.edu/facilities/mailing-services/shipping-request-form/
- Forward a copy of the electronic receipt to Ze Liu or the others if she is out
- A new box will be provided. Pharmacy maintains dry ice for their department; the service group provides dry ice for the rest of the campus. There is a charge for the ice.
- The sample must be ready for pick up by 10 am.
- Ze or the designated person will pick up the sample, complete all additional paperwork and labels, and delivery to the Shipping Department by 10:30 am.
- It is recommended that packages be shipped on Monday or Tuesday. Shipments later in the week may be delayed over the weekend resulting is loss of the sample.
Contact Persons

- Merle J Heineke, Director, Research Laboratories  ph.: 358 7889  email: merle.heineke@wsu.edu
  Shared equipment repairs, hood and autoclave certification, development of Health & Safety department and programs

- Ze Liu, Scientific Assistant  ph.: 358 7633  email: ze.liu@wsu.edu
  Flow Cytometry, Mass Spec, Radiation sampling, dry ice shipments

- Megan Chastain, Scientific Assistant  email: megan.chastain@wsu.edu
  Microscopy, Histology, Imaging

- Chad Trent, Industrial Hygienist  ph.: 368 6699  email: chad.trent@wsu.edu
  Chemical waste removal

- Barry Worden, Fiscal Specialist  ph.: 368 6842  email: barry.worden@wsu.edu
  Replacement gas cylinders

- Solomon Agere, Pharmacy Support Technician  ph.: 368 6608
  Provides Pharmacy Support and Classroom instruction
Culture of Safety

- Safety is everyone’s responsibility. WSU is committed to providing a campus environment that supports the health and safety practices of its community (faculty, students, staff, and visitors) and empowers the community to be responsible for the safety of others. A safe campus environment is a right of employment for all categories of employees. A safe campus learning environment is a right of all involved in education and research.

- Good science is safe science. Safety is a critical component of scholarly excellence and responsible conduct of research.