Lab Safety Modules

- High Voltage Safety with Eric Cornell
- Laser Safety with Henry Kapteyn
- Chemical Safety with Mathias Weber
- Biophysics Safety with Thomas Perkins
- Liquid Helium Safety with Konrad Lehnert
- Clean Room Safety with David Alchenberger
- Machine Shop Safety with Blaine Horner
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**Introduction**

Researchers in laboratory physical sciences are more likely to be killed by electrocution than by radioactivity, intense lasers, or toxins. Electrocution happens if you are careless. There is simply no reason why you should believe that the next researcher to be killed will not be you, or perhaps your lab mate.

The rules listed below are not meant to be a magic procedure to keep you safe. After reading those rules, take a hard look at your lab, then use your intelligence and, yes, your morbid imagination. Look at the high voltage apparatus, and try to come up with scenarios through which it might kill you. Then take precautions to prevent those scenarios.

Electrical current can kill or injure you in two main ways:

1. If lower currents (~50–500 mA) travel through your chest, they can induce fibrillation in your heart. Fibrillation is usually fatal if you are not promptly defibrillated.

2. Higher currents can cause neurological problems or serious internal burns, which are very difficult to treat medically and can lead to loss of limb or life.

A rule of thumb is that an electrical connection routed through your body will have an impedance of about 10 kΩ. But this impedance is dominated by the contact between the conductor and your skin. If your skin or clothes are wet or sweaty, the impedance could be as low as 1 kΩ. Thus, in normal situations, with dry skin, lethal voltages start at about 500 volts. But in the presence of moisture, be it cooling water, laser dye, coffee, coca cola, or sweat, even a line voltage of 110 volts or less can kill you. Be wary also of special situations in which an unusually large area of your skin could be simultaneously in contact with a conductor.

**Basic Tips**

- When working around high voltage, have a buddy in the lab who can rescue if you receive an electric shock. This is especially true if you are debugging apparatus or trying new procedures.

- If you see a colleague getting an electric shock, turn off or unplug the relevant equipment before attempting to assist your colleague, lest you become a victim too. One effect of electric current is to cause spasmodic muscle cramping, which can make it difficult to let go of the object causing you the electric shock, which in your case could be your colleague’s wrist.

- If you and your lab mates will be working around high voltage, sign up for the workshop on using the automated defibrillation machines that are found on the walls near the middle of each lab corridor in JILA.

**Know where the nearest automated defibrillation machine is!**

- The presence of moisture can help electrical current enter your skin and dramatically increase your risk of...
injury from shock. Do not get anywhere near high-voltage devices if your hands are wet, if your clothes are wet, or if there is a puddle of fluid on the floor, on the table, or on the device itself. Note that some high-voltage machinery requires cooling water, and the combination of leaking coolant and high voltage should scream “danger!” to you.

- If you are designing your own circuit and have no need of high currents, install resistors at various places in the circuit and also right at the power supply to limit currents to 5 mA or less if there is a failure in the insulation or in voltage regulation circuitry.

- Grounded shields around high-voltage devices render them harmless. But if grounding is provided by a plain-looking wire, then there is a risk that an inexperienced researcher could unwittingly disconnect it. You are putting that hypothetical young person’s life in danger. Ideally, the ground should be provided by the same plug you use to charge up the high-voltage supply, ensuring that the system will be grounded when the supply is on. Because there is a risk that a high-voltage supply can continue to put out high voltage even after it is unplugged, a secondary grounding wire, prominently labeled with “high-voltage ground, do not remove” is a good idea.

- People do not often walk in front of oncoming buses because they see the bus coming, and they understand at a gut level that if they get in the way of the bus, they will be instantly killed. The great risk associated with high voltage is that there is no such visual signal. A piece of metal at 10 kV above ground will look just like an ordinary piece of metal. The only difference is that if you put one hand on the optical table with the other hand absent-mindedly touching the high-voltage object, you will likely be killed. In laying out a lab that contains high voltage, your job is ideally to totally enclose high voltage with a grounded box. If that is not possible, then you must take steps to make it harder for someone to absent-mindedly touch the high voltage before they’ve had a chance to think about it. Install a plexiglass or other sort of wall. Put in a gate. In any case, make it LOOK dangerous, just as a speeding bus looks dangerous. Put yellow and black tape on it and hang a sign on it that says “Danger, lethal high voltage; don’t touch.”

**Things to Watch Out For**

**Capacitors:** Research scientists are occasionally killed by high-voltage capacitors. We don’t want you to be an example of this. Watch out for two basic modes of danger:

- In high-voltage apparatus, capacitors (that play the roles of removing voltage ripple or providing high-current spikes in a pulse generator) can maintain their charge after the apparatus has been turned off, and even after the device has been unplugged! These capacitors sometimes contain a lethal amount of energy. Thus various cables and electrodes in a high-voltage application can be dangerous even after the machine has been turned off. These regions can be discharged with a grounded probe with an insulated handle. Avoid thinking “this circuit has been designed to discharge the capacitors when it is turned off, and so I don’t need to be careful around it.” As you know, scientific apparatus breaks down all the time. Don’t let a routine equipment failure put your life at risk.

- Large high-voltage capacitors just sitting on the shelf, not connected to anything, can accumulate charge over days, months, or years, through a process that is somewhat obscure. Consequently, large high-voltage capacitors should be stored with a short across their leads. If you encounter a large HV capacitor that has been stored unshorted, approach it with caution: use a screwdriver with an insulated handle to short the contacts of the capacitor before handling.
**Electrical discharges** including ion pumps:

- Ion pumps can undergo a failure mode in which the internal high voltage can discharge rapidly to the case of the pump. In principle, the pump should be grounded by its high-voltage cable. But if this cable or its connector should fail because of age and wear, you could encounter a situation in which your ion pump and possibly your entire vacuum chamber could float at high voltage. Vacuum chambers with ion pumps should have a separate wire connecting them to room ground.

- High-voltage electrical discharges are unpredictable. A discharge can be running between the hot and cold terminals of a gas-filled tube, but then without warning and in a matter of microseconds, the discharge could start running down a tube to a roughing pump, or up a tube to a gas bottle or flow valve. All conducting objects that are in contact with plumbing associated with a high-voltage discharge should either be grounded, or assumed to be (and labeled as such) floating at high voltage.

*After you have finished reviewing High Voltage Safety Module please see Cindy Torres, JILA Reception to complete the high-voltage safety quiz in the Quiz Packet.*
Introduction

Laser safety at JILA is an issue that requires constant diligence. Lasers present a number of hazards in the lab, including potentially fatal electrical hazards, fire hazards when the laser heats flammable material, the potential for body or eye injury due to exposure to laser radiation, the possibility of chemical exposure in the case of gas or dye lasers, and an elevated risk of cataracts and skin cancer. The type of hazard depends on the operating wavelength of the laser.

The most common laser hazard is eye injury. Because the eye’s lens can focus laser light to very high intensity on the retina, even a very small fraction (as low as 0.001%) of the output of a high-power laser can damage the retina. Many injuries could have been prevented with proper eye protection. Yet, it is all too common to see laboratory situations in which the experimenter is not wearing proper eye protection.

The laser eye hazard is an intermittent one — unlike radiation or chemical exposure — and eye protection can be uncomfortable and, in some cases, significantly limit vision. The hazard and the incidence of eye injuries have increased in recent years with the development of higher-power lasers and experiments that make use of a variety of visible wavelengths. For example, the pulsed Ti:sapphire laser operates in the near infrared and uses high-power green pump lasers. Furthermore, the output of this laser can be frequency doubled into the blue and is often used to power optical parametric amplifiers that can produce bright light over nearly the entire region of the spectrum. In many cases, 100% protection from exposure using spectacles becomes impractical or even impossible.

Essential Steps for Providing a Safe Environment

So what is one to do about laser safety? It is possible to work safely with any laser in a laboratory environment, but only when the researcher is fully knowledgeable of the hazards, takes all practical steps to prevent exposure, and takes responsibility for laser safety in his or her laboratory. The essential steps in providing a safe environment are:

- Know what types of lasers are used in your area and where the major hazards originate. What wavelengths do lasers in your lab emit? Which sources have average or peak powers that present a hazard?

- Know the basics of laser classification. Laser classifications that require significant protective measures include class 3(b) and class 4 lasers. For class 3(b) (5 mW–0.5 Watt average power), measures that prevent direct eye exposure to the beam are called for. For class 4 lasers, eye protection is needed in the case of an exposed beam. Most lasers in JILA labs are class 4.

- Know what types of laser protective spectacles and goggles are appropriate protection, and under what situations.
  - Complete protection generally requires spectacles with optical density (OD) in the range of 3–6 in the wavelength range where the hazard exists. Laser goggles are always marked for optical density in the range where they protect, but sometimes the markings can be brief and occasionally cryptic.
Take the time to know what protection you have available in the lab.

- The exact OD requirement for your laser experiment depends on whether your lasers are continuous wave (the lower end of this OD range) or pulsed (the higher end of this range). Generally, mode-locked lasers with repetition rates >1 MHz can be considered to be continuous wave. Further details on how to determine eye protection requirements can be found in the laboratory safety section in the JILA library (S-105E) and online at http://euverc.colostate.edu/people/students/students_only.shtml.

- Make sure that the spectacles you use fit properly. If they fall off your face, this can actually increase your hazard, as a beam can reflect from the spectacle into your eye.

- **Equally important** to eye protection is the practice of proper “laser hygiene” in the laboratory. Laser spectacles are the last line of defense. The first line of defense is simply to never create a situation where a beam could intersect with your eyeball.

- Ideally, an experiment will be set up so that the beam path is as low as possible on the optical table, with the optical table itself at waist height. Laser beams should always be kept parallel to the plane of the table to minimize the possibility that some reflected light could travel to eye height. If it is absolutely necessary to use an out-of-plane beam, special care must be taken to identify and block any stray reflections or residual beams that could pass through an optical element.

- All primary and stray beams on a table should be blocked before leaving the edge of the table. If the experiment needing the laser beam is not on an optical table, access to the beam transport region should ideally be blocked so that no one can walk through the beam. If this is not possible permanently, use a rope of chain with a laser hazard sign. Eye level beams, propagating in open space in the lab, are categorically unacceptable. Any situation where a “normal” range of body movement might place the eyes in a beam path is unacceptable, even if spectacles are worn religiously. Many eye injuries have happened to people wearing protective eyewear. Setups that require particular attention are vacuum viewports that a beam passes through, lenses, and removable optical elements such as optical filters. Stray reflections from these items can often be unpredictable. **Do not wear jewelry (including watches) in the lab when you are working on an optical system.**

- Fully enclose laser beams wherever possible. This is especially important where a wide range of laser wavelengths is used. For example, for the common Ti:sapphire laser pumped by 532 nm YAG lasers, if the YAG pump laser beams are fully enclosed, eye protection is necessary only for the Ti:sapphire (~700–900 nm IR) during routine use. Spectacles for Ti:sapphire only are relatively transparent in the visible region of the spectrum, and thus are much more likely to be routinely worn than spectacles that protect against both IR and green. The latter are like wearing dark sunglasses in the lab.

- For optical experiments with sensitive detectors, do not rely on a darkened room to limit detector noise. Shield your detectors from room light. A dark room will dilate the pupils, collecting more hazardous laser light—and also make it tempting to take off your spectacles to see safely.

- Be aware of the fact that you are in a laser lab in the way you behave. For example, it is good practice to avoid leaning over in the lab. **DO NOT** use your eyes to sight down a beam path, even if the laser is off. If you get into the habit of this, you might absent mindedly leave the laser on, and once is all it takes to do damage. If you need to pick up something from the floor, face away from the optical tables as you lean over.
- Do not operate a high-power laser system when you are not in an alert state. Many accidents happen when the operator is fatigued or slightly ill and is simply not thinking clearly about safety issues.

Finally, *take responsibility* for possible exposure of others:

- Although it is good safety practice to leave your lab door open or unlocked in case of emergency, passers-by should not be able to see the table or any part of the beam path.

- Entry to the laser area should be accompanied by hazard warning signs.

- Any furniture in the lab should be placed in such a way that people using it will not be at risk of exposure. For example, computer tables at standard height place the head at beam level if people sit at them. Use opaque dividers, or high tables for the computers. Drafting chairs can provide seating that can be safely used in the lab without bringing the face down to eye level.

- Make sure that you are certified to work on lasers in the lab by taking the laser safety test (with appropriate documentation). This test is different than the short quiz accompanying this safety module. Make sure that any visitors working in your lab have also taken the laser safety test, even if they have had safety training elsewhere.

*After you have finished reviewing Laser Safety Module please see Cindy Torres, JILA Reception to complete the laser safety quiz in the Quiz Packet.*
Introduction

In principle, no chemicals used in laboratory physical sciences are completely harmless, and accidents involving chemicals often result in loss of life or limb. Accidents are bound to happen if you are careless, and the next researcher to be killed, blinded, poisoned, or seriously injured for the rest of her/his life could easily be you or your lab mate. The rules listed below are not meant to be complete, but rather were written to serve as sensible guidelines to good laboratory practice. After reading those rules, take a hard look at your lab and your “usual” lab practices. Then use your intelligence and be as paranoid as you can about what could happen. Then take precautions to prevent accidents.

First and Foremost: Always Know What You Are Doing!

Before you work with a chemical, be sure that you know what kinds of hazards it constitutes. You can learn about chemical hazards in Material Safety Data Sheets (MSDS). Your lab must have an MSDS for each chemical your lab uses, and everyone in the lab must know where the MSDS are. Keep your MSDS library up to date. A very useful resource is the European Union’s “R- and S-phrases,” which detail the nature of special risks attributed to substances you are using. These risks are also often listed on the container. For more information, see CU’s Environmental, Health, and Safety website.

If you are using a chemical for a reaction, you must know ahead of time how the reaction proceeds:
- Does it generate heat?
- Is it violent?
- Does it produce toxic gases?
Always label chemical containers, EVEN IF THEY JUST CONTAIN WATER!

Material Safety Data Sheets (MSDS)

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Hazardous Wastes

If you work with chemicals of any kind, you are automatically a Hazardous Waste Generator, according to the definition of CU Boulder. This means that you MUST take a Hazardous Waste Generator Training. The training gives you a few good procedures to work with. Be sure and follow these simple rules:

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1 Link to http://en.wikipedia.org/wiki/Material_safety_data_sheet
2 Link to http://www.colorado.edu/ehs/resources/guidance.html
3 Link to http://en.wikipedia.org/wiki/Risk_and_Safety_Statements
• Do not flush solvents or other hazardous wastes down any sink.
• If you clean out glassware, use hazardous waste containers for the waste materials (including the solvents).
• Broken glassware or syringes are hazardous waste, even if they are clean. Do not discard them with the regular trash, because janitors might cut themselves!
• Make sure that you store chemicals properly (see Hazardous Waste Generator Training\(^4\)).
• Do not store chemical containers on the floor, creating both tripping and chemical hazards.
• Store different classes of chemicals separately, i.e., acids separate from bases, flammables separate from oxidants.
• Keep containers with flammable substances (e.g., solvents, liquid propane, and flammable gases) closed at all times except when you actually use them.
• Any material on the EPA’s “Acute Hazard List”\(^5\) should not be brought onto campus without prior written notification to and approval from the JILA Safety Officer and UCB Environmental Health and Safety. Anyone working with or in the vicinity of these materials must have carefully reviewed the relevant MSDS and fully comply with the MSDS guidelines. Empty containers that have held these substances must be triple rinsed with an appropriate solvent and discarded as hazardous waste (including the solvents). If possible, use other substances.

**In case of any accident, remember the phrase: Life Safety First**

### Chemical Emergencies and Spills

Know where the nearest fire-extinguisher, eye-wash fountain, and chemical safety shower are before you use any chemical. Read and understand the Emergency Action Plan (white or orange sheet of paper that should be close to the lab exit and/or phone in each lab).

If a chemical spill occurs, the right response depends on the nature of the spilled substance and on the size of the spill. The MSDS give advice on how to clean large spills, and they tell you what kind of hazards you face. Make sure that the people around you know of a spill (even a minor one), and keep other people from entering the affected area.

- **For very minor spills** (e.g., a few ml of nontoxic and noncorrosive liquid or a few 100 cm\(^3\) of gas at a few Torr), clean up the spill, open the windows, get a fan, and blow out the lab. Remember to collect the cleanup material in a hazardous waste container. Don’t breathe in the fumes. Hans Green (B128, x27776) maintains supplies for neutralizing small spills of solvents, acids, bases, and mercury. He can render technical assistance if needed. For example, for a small spill of ethylene glycol (a few ml), it is OK to neutralize the spill and collect the waste in a compatible container for hazardous waste.

- **Larger spills** can constitute a true emergency. If you drop a gallon-sized bottle of solvent and it breaks, you must evacuate the lab and alert Randall Holliness (S175, x24020) to contain and clean up the spill. Don’t breathe in the fumes from a large chemical spill.

- **In case of a major spill releasing toxic or corrosive fumes (gases)**, evacuate the lab immediately and close the lab door behind you. Activate a yellow pull-box on your floor. Evacuate the building (labs and offices), and call 911 from a safe location.

After hours, or if you cannot reach Hans, Dave, or Randall, call Facilities Management (x25522) and describe the problem.


\(^5\) Link to [http://www.colorado.edu/ehs/pdf/EPAplist.pdf](http://www.colorado.edu/ehs/pdf/EPAplist.pdf)
Spills on Clothes and Skin

- Your clothing may constitute a hazard if you work with chemicals.
- As a chemical spill will often hit the floor, this hazard starts with your feet and legs. Wearing flip-flops or other open sandals in the lab where you or your lab mate work with chemicals can expose your skin to a chemical spill, which can induce chemical burns (e.g., from acids or bases) or poisoning (from chemicals that can be absorbed through your skin). Always wear closed toed shoes when in a laboratory setting.
- In case of a fire, clothes with a high content of synthetic fabrics can melt and fuse to your skin before you can take them off. Cotton is a better choice.
- No matter what you wear, if you have a chemical spill and get a chemical on your clothes, remove the affected clothes immediately. Don’t put them back on, even if a spill appears to have dried, because there may be harmful residues.
- If a chemical has been spilled on your skin, rinse immediately, continuing to rinse for >15 minutes with lots of cold water. If your eyes are affected, use an eye-wash fountain. Follow the instructions in the MSDS.
- Do not hesitate to seek medical help if the MSDS instructs you to do so. Let your lab mates and your PI know what happened.

Protective Barriers

Always use protective equipment if you work with chemicals. The minimum protection would be to wear a lab coat, vinyl or latex gloves, and protective eyewear. Some situations may warrant a plastic face shield in addition to protective eyewear or goggles. Note that glass is not a good protective barrier, because it can shatter in explosions, producing dangerous flying shards. Contact lenses can damage the cornea when chemicals or vapors are trapped behind them. Use prescription goggles or safety glasses instead. In some cases, vinyl or latex gloves offer little protection, especially if you work with organic solvents. If you spill a droplet on a glove, remove the glove immediately and put a new one on. Do not open lab doors or operate computers while wearing gloves from chemical work. You might unwittingly contaminate door knobs and keyboards this way, and other people may come in contact with harmful substances.

Diluting Acids or Bases

If you work with acids or bases, you often need to dilute a concentrated stock. In many cases, this leads to considerable heating. Always put the water into the mixing container first, and then slowly add the concentrated acid or base you want to dilute. Otherwise the heat of the hydration reaction can lead to local superheating of the mixture, resulting in an explosive release of superheated material, which can splash acid or base over you.

Remember: “Do what you oughta, add acid to water.”

Highly Corrosive Substances

- Etching or thoroughly cleaning glassware or semiconductor surfaces often call for very aggressive treatment, e.g., with hydrofluoric acid, aqua regia, or “piranha” solution. Some of these aggressive substances, especially “piranha” solution, can attack plastics. If you have never worked with such a substance or if your experience has been a few years ago, talk to David Alchenberger (S120, x22389) before you use them. He has good practical advice. In a corrosive-substance spill, vinyl or latex gloves are of little use. Wear thick rubber gloves. If you or anyone in your vicinity works with HF, familiarize yourself with procedures for handling this extremely toxic substance. Tubes of hydrofluoric acid burn cream are in B128 and in B216.
- Dilute concentrated corrosive substances, such as with acids and bases, before disposing of them in a hazardous waste container. When rinsing glassware that contained concentrated corrosive substances:
• use baking soda to neutralize acids (e.g., aqua regia or piranha solution) until they stop fizzing.
• use diluted vinegar to neutralize bases (e.g., concentrated KOH or NaOH solutions).

Many metals will be corroded instantaneously upon contact with acids, generating H₂ gas, resulting in an explosive mixture with air.

**Alkali Metals**

- Many metals and metal compounds are toxic. Alkali metals present an additional danger because of their high reactivity. In particular, many groups in JILA work with alkali metals (Li, Na, K, Rb, and Cs).
- You should always wear a face shield and protective goggles, gloves, and a lab coat when working with alkali metals.
- Alkali metals react spontaneously and violently with water as well as with short-chained alcohols (e.g., methanol or ethanol), generating H₂ gas (which can lead to explosions) and metal hydroxides (which are strong bases and highly corrosive). Never bring a piece of alkali metal or a part of your apparatus that is contaminated with alkali metals into contact with water or short-chained alcohols. Alkali metals can even react explosively with ambient humidity (even here in Boulder).
- Obviously, never try to extinguish an alkali metal fire with water, use the correct type of fire extinguisher!
- If you need to clean away alkali metals from equipment parts, use a long-chained alcohol bath (e.g., isopropanol) for a few hours. Remember that the isopropanol has now become a hazardous waste.

**Gas Cylinders**

- Nearly all JILA labs use compressed gases. No matter the substance, gas cylinders are hazardous, because the main valve can be sheared off if they topple and strike a bench, laser table, or apparatus. A gas cylinder with a sheared-off valve is a rocket-propelled projectile that can break through concrete walls. Therefore, gas cylinders must always be secured, i.e., strapped to something like a wall that cannot move if the valve is sheared off.
- When you transport gas cylinders, always put on the cylinder’s safety cap before you move it, and only use cylinder carts for transportation. Don’t “roll” large cylinders on their bottom edge; this is an unstable way of moving gas cylinders.
- Always use the proper reducing valves, pump out the gas lines, and check for leaks before opening a container releasing gases or fumes. These safety precautions are especially important if you work with reactive, toxic, or corrosive gases such as NO, NO₂, CO, or H₂S (there are many others!). For some of these (e.g., CO), commercial detectors can be installed in the lab.
- Remember that even if the gases in question are nontoxic (e.g., rare gases or N₂), they constitute a hazard, because they can suffocate you. Never leave flowing gases unattended. If the pumps fail (e.g., because of loss of electrical power), there can be a dangerous buildup of pressure in your apparatus.
- And, remember to keep flammable gases and oxygen or other oxidizing agents far apart in the lab.

**Fumes**

Many of the liquids we use at JILA (and sometimes solids, too) have high vapor pressures at room temperature. Inhaling those vapors is often harmful or toxic, and many are flammable. Use a fume hood for work with such substances. Note that the hood will not work properly if the sash is too high up. Fume hoods have marks on the sides indicating the proper position of the sash for operation. Solvent fumes (e.g., diethyl ether) can make highly explosive mixtures with air, so do not leave bottles open. If you use the common fume hood in the X-Wing, please be aware that any storage must be approved by David Alchenberger (S120, x22389) first. All containers you store there (even for only a few minutes, even if they only contain water) must be marked with the content and with your name.
Solvents
Many solvents are carcinogenic (e.g., benzene, toluene) or damage the liver (e.g., CCl₄). Many are absorbed through the skin, and many (e.g., methanol, CCl₄) are toxic. Most laser dyes are carcinogenic as well. Take care not to spill these solvents on your hands. In fact, all organic chemicals should be regarded as toxic unless you know otherwise (e.g., from reading the appropriate MSDS).

Radioactive Materials
Some labs work with radioactive substances, especially metals. At JILA, these materials are usually only mildly radioactive, but that does not make them harmless. An example is thoriated tungsten, used for electron gun filaments. Do not grind or sand such materials to avoid generating dust. If you spot-weld thoriated-tungsten filaments, wear a breathing mask to avoid inhalation of dust. Also, take care not to ingest radioactive substances such as thorium. Lungs and other internal organs can be penetrated by alpha radiation, increasing the risk of cancers of the lung, pancreas, and blood. Exposure to thorium internally leads to increased risk of liver disease.

After you have finished reviewing Chemical Safety Module please see Cindy Torres, JILA Reception to complete the chemical-safety quiz in the Quiz Packet.
Introduction

Hazards associated with biophysics at JILA should be minimal, assuming young scientists have proper training with the methods and reagents we use. These methods and reagents are distinct from those associated with standard physics and chemistry experiments. Here we outline the simple procedures necessary to minimize any dangers to biophysics lab members and other JILAns.

By number, there are many more E. Coli cells in our bodies than human cells

The simplest and most important procedure is to NOT wear gloves in general building areas. In biophysics, gloves are used to protect the biological experiment from dirty hands and skin. Bacterial co-habitation is common and indeed important for human health. However, it is detrimental to most biophysical experiments. A bottle of aqueous buffer left out and open at room temperature will be seeded by bacteria or other simple organisms floating around in the air. Such contamination ruins many experiments as many new graduate students learn.

Traditional “starter” for sourdough bread can be made by setting out a mixture of flour and water for 2–3 days in a warm place, allowing for seeding of wild yeast.

So, biophysicists use gloves all the time. However, others in the building do not know if you were just handling a dangerous chemical. So, whenever possible, do not wear gloves for getting ice, etc. This prohibition includes the lab as well. If the phone rings, remove your gloves from your hands before answering it. Gloves are disposable and cheap. Prevention of cross contamination from the phone (which is likely the second most dirty thing in the lab after your keyboard) is important. Also, to reduce the possibility of contamination and anxiety of others, do not sit at key boards and wear gloves unless absolutely necessary.

Basic Safety Tips!

- **Cleanliness.** This applies to all aspects of biophysics research. The two most important areas are buffer-preparation areas and fume hoods. When weighing out chemicals, always clean up any residue, even if you are weighing out NaCl (table salt); the next person to use the work station doesn’t know table salt from a much more dangerous chemical. They are forced to treat the unknown chemical — a white powder has no sign on it saying “I’m salt” — with the greatest caution. So after making buffer, always wipe down the area and visually inspect the work area. There should be absolutely zero residue on the scale or the surrounding area.

  Fume hoods are where dangerous chemicals and acids are handled. They should always have a minimal amount of material in them. **DO NOT LEAVE** them a mess. When you walk up to a fume hood, it should be neat. All material used in the hood should be labeled and be in secondary containment, if needed.
As with most potentially dangerous operations, you will need training and supervision the first time you perform a fume-hood procedure. It is a good idea to run through the steps in a “dry run” to make sure that you have sufficient space and equipment is easily at hand to do the whole procedure. You should also plan in advance for an accident by answering such questions as: Where is the nearest eye wash or safety shower? Can you get there with your eyes closed? Is the path unobstructed by boxes, chairs, etc.?

- **Label everything** (even water) with contents, a date, and your initials. Here’s why: Aqueous buffer is transparent. If there is a beaker with a clear liquid in it, other users have no idea if this is water or something more dangerous. This can result in high anxiety if there is a spill. Thus if you need to leave a beaker in the fume hood uncovered, you should put tape on the beaker or a piece of paper taped on the work surface nearby, with the following information: the beaker’s contents, your name, where you are, and when you will be back.

### Special Safety Issues

- **Sharps:** Pipette tips, razor blades, and needles.
  - Pipette tips are made of plastic and may not seem like a true hazard, but there have been documented cases of janitorial staff’s hands being punctured by improper handling of trash. The physical trauma may be small compared to the potential unknown chemical contents of the pipette tip. This is exacerbated if the room occupants are not in the room at the time of the incident. From a number of such incidents in research setting, it has been established that pipette tips (even those used to manipulate nontoxic liquids like water or buffered saline) are not to be disposed of in the regular trash. Rather, for tips used with a nontoxic substance, they should be collected and put into a “broken glassware” type cardboard box. They do not need to go into a red “sharps” container. Sharp containers are appropriate for razor blades, syringes and needles, and pipette tips contaminated with hazardous chemicals.
  - Never recap a syringe needle. This is very dangerous. Needles should go directly into the sharps container. If for some reason, this is absolutely mandatory (and I do not see why), place the cap on the work surface, remove you hand, insert the needle into the stationary cap while your free hand is far removed. This minimizes risk but is not recommended.

- **Base and acid cleaning of glass:** It is crucial for many biophysical experiments for glass surfaces to be free of any contaminants. The common technique for this problem is to etch the glass in either a strong acid or a base. Such solutions pose a moderate risk and care must be taken when using them. Always wear personal protective equipment, including closed-toed shoes, long pants, goggles, gloves, and a lab coat. Be cognizant of where others in the lab are, so as to minimize any potential for bumping or being bumped while using these strong acids and bases. Also, make sure to properly dispose of these chemicals after use. DO NOT leave strong acids or bases on the stir plate or fume hood without proper labeling (see above).

- **Chemical risks:** In general, try to use the least toxic chemical necessary to get the job done. For instance, ethidium bromide is a DNA dye used for gel electrophoresis. It is still widely used even though there are new effective DNA dyes that are significantly less toxic. The new dyes will not cross the cell membrane of live cells.
  - The only acutely toxic chemical widely used in biophysics at JILA is sodium azide (NaN₃). Be very careful with it, and follow established safety protocols for tips and other parts that come into contact with NaN₃. Sodium azide prevents bacteria from growing. However, a safer alternative is to filter sterilize your solutions through a 0.2-µm filter or autoclave them and use sterile lab techniques. For beads and certain applications, however, sodium azide is necessary.
- **Autoclaves**: Autoclaves use high temperature and high pressure to sterilize material (buffers, tips, glassware, etc.) for use in biophysical assays. As such, they represent a safety hazard. Never use autoclaves without proper training. At a minimum,

  - Always wait for autoclaves to exhaust (interlocks should make this happen).
  - Open the autoclave door with proper gloves.
  - Stand away in case the door is under pressure, and hot steam comes out.

Tips, empty glassware, etc. are autoclaved with a dry cycle that has a final drying time. Liquids are autoclaved with a liquid cycle that has a slow exhaust to prevent boiling over. Biohazardous material, e.g., bacterial culture plates, pipettes, and pipette tips used with them are autoclaved in special disposal bags placed in an autoclave tray or tub such that the bag is not touching the inside of the autoclave (melted plastic bags are very difficult to clean from the autoclave, as you will find out). Full instructions for the proper disinfection and disposal of biohazardous waste can be downloaded from CU’s Environmental Health & Safety web site.

After you have finished reviewing Biophysics Safety Module please see Cindy Torres, JILA Reception to complete the biophysics quiz in the Quiz Packet.
Introduction
This document is intended to protect staff from hazards associated with the use of liquid helium. It establishes criteria for the safe use of helium. It does not replace mandatory training.

Hazards
The primary hazards associated with liquid helium are:

- cold burns (frostbite).
- asphyxiation.
- explosion from overpressure.
- chemical explosion and fire.
- crush injuries.

Training
Before using liquid helium, scientists and staff must be trained in its safe use. This training should make users familiar with:

- properties of the material in its liquid and gaseous states.
- safe operation of any equipment that uses liquid helium.
- hazards and failure mechanisms for specific equipment.
- location of protective equipment.
- action to take if there is a problem with the storage of helium, including leaks and blockages.

In addition, all JILA scientists and staff who work in a lab that uses liquid helium must be trained to respond appropriately to an asphyxiation hazard.

Equipment
Always use equipment designed specifically for storing, transferring, and using liquid helium. Any manufacturer of such equipment will provide detailed instructions in the safe use of their product. Read, understand, and follow those instructions. The guidelines given here supplement those instructions; they do not replace or supersede them.
Guidelines

- **Proper handling of storage dewars:** Helium storage dewars are heavy steel cylinders on wheels. They are easily tipped over. Often they have damaged wheels, like an old shopping cart. As such, they present a substantial risk of crush injuries to hands and feet. Furthermore, they can easily fall down stairs, maiming and killing anyone on those stairs. When handling dewars:
  - Walk slowly, and never run with a dewar.
  - Use handles at the dewar’s side to move it.
  - Never pull the dewar by the ring at the very top. (This ring isn’t a handle; it protects the valves.)
  - Avoid the tops of stairs and steep ramps. Use a freight elevator to go between floors.
  - Take particular care not to tip the dewar when crossing an uneven floor such as a door jamb.
  - Don’t leave a dewar near the tops of stairs or ramps!

- **Proper use of liquid helium:** When you receive a dewar, make sure it does not have an ice plug already. Keep a log of when you transfer helium by writing the date and time on the dewar’s tag. If the dewar needs to be serviced (e.g., cracked gaskets need to be replaced or broken wheels need repair), inform the vendor by noting the damage on the dewar tag.

- **Avoiding cold burns (frostbite):** Cold burns are a common injury from liquid helium use. These injuries occur when skin contacts cold surfaces or the cryogen itself. Wear leather or cryogenic gloves and side-shielded safety glasses when transferring liquid helium from one vessel to another. The greatest risk of a cold burn doesn’t come from the liquid helium itself but from a high velocity jet of the cold gas. Such jets occur when a dewar has a gas pressure > 1 psi. This condition always exists when transferring helium from a dewar. Often multiple-nested quick-connect fittings are required to step the diameter of a transfer line up to the diameter of the liquid extraction port on a helium dewar. These fittings easily and unexpectedly separate, emitting a jet of cold gas past the hands of anyone holding the transfer line. Also, dewars improperly stored with all of their valves closed will have a high pressure of cold helium gas eager to escape violently. They will emit a jet cold gas upon opening any of the valves. Such jets are likely when clearing an ice blockage from a frozen dewar.

- **Preventing explosion from over pressure:** Vessels that store liquid helium are potential pressure bombs. The helium gas evolved by the boiling liquid must have a way to vent to the atmosphere lest the pressure in the vessel rises to the point that the tank bursts. If air is allowed to enter the storage vessel, it will freeze, eventually blocking the vent with frozen air. Consequently, vessels should be vented through a one-way valve. Unfortunately, ice blockages are still a common occurrence. They occur either because a user has left the valves on a dewar open to air or because the rubber gaskets and o-rings on the dewar have failed. If you plan to work with liquid helium, you must first be trained by an experienced user on how to clear these blockages. Any lab that uses liquid helium must have the proper tools to clear a blockage. Keeping a log for each dewar is also crucial. If you discover a dewar that may have been plugged for more than ten days (check the log), don’t try to clear the plug. **If you cannot determine that a plugged dewar has been plugged for less than 10 days, evacuate the lab that contains the dewar, close and lock the doors to the lab, pull the fire alarm, and remain available to describe the situation to emergency personnel.**

A vessel whose interior is still cold, even though all the liquid helium has evaporated, is still an explosion
hazard. The cold surfaces can cryopump an enormous volume of air, which will expand dangerously upon warming. Finally, the vacuum jacket that encloses all liquid helium vessels is itself an explosion hazard. A small leak of air into that vacuum jacket will freeze, only to expand violently when warmed. All manufactures include some type of overpressure safety valve (often it’s a small disk that shatters if the pressure grows too large in vacuum space) on their vacuum jackets. Never interfere with these, and never use a vessel where this safety feature is damaged or absent.

- Preventing explosion and fire from high oxygen concentration: Any surface cold enough to liquefy air has the potential to increase the oxygen concentration to a dangerous level where it can cause a chemical explosion or fire. Of particular concern are vessels in which the liquid helium has evaporated but are still cold. As liquid air warms, the oxygen boils away first; the oxygen concentration in the vapor can increase above the 21% of air. Never let air enter a cryogen vessel until it is entirely warmed to room temperature. If you discover condensed air in a dewar, boil it way by blowing helium gas down into the vessel.

Working Near Liquid Helium

- Preventing Asphyxiation: Any volume of liquid helium can turn suddenly from a liquid to a gas that occupies 800 times more volume. When large volumes of liquid are stored in an enclosed room this presents an asphyxiation hazard. As a conservative rule of thumb, a potential asphyxiation hazard exists when the volume of a room is less than 80,000 times greater than the volume of helium liquid in the room. If an asphyxiation hazard is present, installation of an oxygen alarm is mandatory. Fortunately, when liquid helium turns to a gas suddenly, it is a profoundly noisy and startling event. If this occurs in an enclosed space, leave that room and leave the door to the room open. Remain nearby to warn anyone against entering the lab. Stay out of the room until the oxygen concentration has returned to normal. Don’t make the mistake of assuming that your body will sense the lack of oxygen in time for you to leave the room! The instinct to breathe (such as when holding your breath) doesn’t arise from lack of oxygen, but from the increased carbon dioxide concentration in your blood. If you feel dizzy from lack of oxygen, it’s too late; you have about one second of consciousness remaining.

After you have finished reviewing Liquid Helium Safety Module please see Cindy Torres, JILA Reception to complete the liquid-helium quiz in the Quiz Packet.
**Introduction**

Use of the JILA Clean Room poses its own set of unique safety issues. By its very nature, the clean room is a positively pressurized, closed environment using partially supplemented, recirculating filtered air. Approximately one-third of the air in the room is vented to the outside and the remaining two-thirds is mixed with fresh air and returned to the room through High Efficiency Particulate Air (HEPA) filters. Noxious fumes not captured by the wet processing stations could be reintroduced for several minutes, albeit diluted with each room air exchange. Because the pressure in the lithography bay is positive relative to the other bays and corridor, these fumes could also find their way into adjacent sections of the cleanroom.

The lithography bay of the clean room is lighted with amber safe lights to prevent pre-exposure of the photoresists used in the room. The amber color makes true color rendering difficult, so special care must be taken to correctly identify storage containers.

Hydrogen fluoride-bearing solutions, such as Buffered-Oxide Etchant, are used for some processes in micro/nano fabrication. Peroxide-bearing solutions such as peroxymonosulfuric or Caro’s acid, often referred to as “piranha” solution, is a strong oxidizer used for cleaning and etching. Both are occasionally used in the lithography bay. These dangerous chemicals require special care and attention, both by the user and by others working in the area. A special section in this module titled **Extraordinary Hazards** is dedicated to these materials.

Users should also be aware that there are two radioactive Polonium-210 alpha-emitter sealed sources in the lithography and, on occasion, fabrication bay.

Clean-room users come from varying disciplines, with some people being more familiar with chemistry than others.

**General Policies and Protocols Regarding the Use of the Clean Room**

Access to the clean room will be granted only to those who complete the requirements as outlined in the JILA Clean Room New User Cover Sheet, which includes JILA Safety and EH&S¹ training and quiz obligations. An initial walk-through with the cleanroom manager is also required. There are no exceptions to this policy.

With the possible exception of a water bottle kept in the gowning area, food and beverages are not allowed in the cleanroom.

The gowning protocol, which entails donning a gown, head and facial hair covers, gloves, booties and safety glasses, is not only meant to maintain the low-particle integrity of the area, but also provides some personal protection.

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¹ Link to EH&S's Hazardous Material/Waste Management [http://www.colorado.edu/ehs/resources/guidance.html](http://www.colorado.edu/ehs/resources/guidance.html)
The cleanroom manager is not responsible for keeping users current on EH&S requirements regarding Hazardous Material/Waste Management. Before using the clean room, you must consult with the HMWM proctor for your lab and complete appropriate training and documentation to be in compliance with EH&S rules governing Hazardous Waste Generators.

Due to the static eliminators, users of the lithography bay and those wishing to use the eliminators in the fabrication bay must complete the EH&S Radiation Safety\(^2\) training and quiz.

In general, it is good practice to let someone know that you are going to work in the clean room and when, approximately, you will return. In addition to the advice set forth in UCB’s EH&S Laboratory Safety Guidelines and JILA’s Safety Handbook\(^3\) and Chemical Safety module, the following rules for the use of the clean room must be observed:

Do not use HF anywhere other than the wet processing station designated for HF use only. Do not use this station for anything else. A one-person-at-the-bench policy for the other stations applies for processes and chemicals deemed especially hazardous. Piranha use is subject to this policy. Use the stainless steel station for solvent cleaning, spin coating, and developing only. Solvents are not to be used at the acid station and vice versa.

Except for small solvent squirt bottles, all chemicals are sequestered to the lithography bay, Room X121D. The chemical inventory for that room is posted in the front section of the MSDS binder. Chemicals other than those in the room’s inventory are not to be introduced, used, or stored without approval of the lab manager.

Approved, but non-inventoried, chemicals must be removed from the room at the end of the work session.

Chemical compounds or solutions made from inventoried constituents must be brought to the attention of the lab manager.

Chemical containers must be covered and labeled using lab-approved labels with the chemical name, date, and user’s name. Unattended containers, such as Petri or crystallization dishes used during a lift-off process, for example, must be similarly covered and labeled.

Chlorinated solvents are not allowed in the room.

Containers of used chemicals ready for disposal are to be clearly labeled and placed in the agreed collection site for transfer to the Satellite Accumulation Area by the lab manager. Use the word “Used” instead of “Waste” on labels for containers in the lithography bay. The SAA is the only place where waste chemicals can reside. Heated vapor deposition (HMDS) and passive vapor etching (XeF2) are not allowed without permission of the lab manager.

No glass or metal closed-vessel reactors are permitted.

Lecture bottles, whether full or empty, need to be stored in the gas cabinet beneath the reactive-ion etcher.

Repeated violations of rules and policies or consistent lapses of common sense and courtesy to others will result in a loss of the privilege to use the facility. All users are within their right to question another person’s unsafe practice or unauthorized access. Reporting infractions in person or anonymously by means of the notice board located in the gowning room is encouraged.

\(^2\) Link to EH&S Laboratory Safety Guidelines [http://www.colorado.edu/ehs/resources/guidance.html](http://www.colorado.edu/ehs/resources/guidance.html)

\(^3\) Link to JILA Safety Handbook [https://jilawww.colorado.edu/member/cgi-bin/wiki/wiki.cgi?JILA_Handbook_PDF](https://jilawww.colorado.edu/member/cgi-bin/wiki/wiki.cgi?JILA_Handbook_PDF)
Standard Safety Procedures

➢ Know your environment
   • Familiarize yourself with the location of the first-aid kit, fire extinguisher, eye washer, face shield, calcium gluconate antidote, isotonic skin and eye wash bottle, the yellow Material Safety Data Sheet (MSDS) binder, telephone, and fire extinguishers. These are pointed out in the initial walk-through.
   • In the event of a chemical splash to the face, for example, you may need to “feel” your way to the eye washer.

➢ Know your circumstance
   • Take note of any spills and containers on the bench before you get started.
   • pH test paper located under the acid processing station can help identify spills.
   • Give yourself plenty of space to work in, even if it means moving hot plates or other devices you won’t need.
   • If your process allows you to work with another person at the bench at the same time, know what they are using.

➢ Know your process
   • Do not undertake any chemical process or mixing without knowing what to expect and what might go wrong. For example, diluting a large amount of acid in water may heat the beaker or evolve fumes to a surprising level.
   • Become familiar with the materials you are about to use by reading each MSDS.
   • Wear safety garments, accessories, and gloves appropriate for the materials used.

➢ Avoid using incompatible materials at the same time.
   • Keep acids away from solvents and bases.
   • Store chemicals in their designated cabinets, keeping incompatible materials well separated in the “Used Chemicals” cabinet.
   • Bulk acids are always stored in the acids cabinet. Acids in use are kept in the storage area beneath the acid bench.
   • Peroxides are stored in the vented box within the acid bench.

Extraordinary Hazards

The dangers of using hydrogen fluoride-bearing and peroxide-bearing solutions cannot be overstated. Ad-hoc instruction provided by lab personnel in the preparation, use, and storage of these materials is required.

Hydrofluoric Acid
HF is a contact poison, and the most toxic compound in the clean room. It is used almost exclusively for etching silicon dioxide. Because it affects nerve function, contact with the skin may not be immediately noticed as with the strong acids. It is readily absorbed into the skin and can cause deep-tissue damage. The fluoride ion reacts with calcium in bone, resulting in osteoporosis, and it can react with calcium and magnesium ions in the blood, causing cardiac arrest. The fumes can be just as harmful as contact with skin. This material is potentially lethal. The death of a custodial staff member at a research lab was directly attributed to negligent disposal of cleaning materials used in wiping up an HF spill. The lithography bay has a bench dedicated exclusively to HF processing. All HF-bearing solutions are to be stored in the lower part of this bench.
Given its toxicity, one may want to consider alternatives to using HF such as reactive ion etching or a lift-off technique that involves selective deposition rather than etching of silicon dioxide.

- **Protocol for using HF:**
  - Familiarize yourself with the properties of HF by reading the MSDS.
  - Use only in the designated HF processing station. Avoid the fumes at all cost.
  - Always wear protective barrier garments and a face shield when handling or using HF. Latex or nitrile gloves can be thought of as first-order protection only for diluted (<5%) HF. Silver Shield gloves must be used when handling concentrated (48%) HF. Silver Shield gloves and a plastic apron are located in the storage area under the acid processing station. The face shield is stored on the wall between the benches.
  - Tuck coat sleeves into the gloves to prevent any liquid from wicking onto the sleeves.
  - HF etches silicon dioxide, the primary component of glass. Do not use glassware for HF. Instead use Nalgene or Fluoroware vessels.
  - When finished, carefully pour the used HF in a properly labeled Nalgene container and store in the secondary container labeled “Hydrogen Fluoride Containing Solutions Only” in the lower part of the HF bench.
  - At the end of the HF session, check for holes in the gloves and any of dampness on clothing.

- **In the event of exposure to HF:**
  - Remove any affected clothing and set aside as hazardous material.
  - Rinse the contact site with water immediately.
  - Liberally apply calcium gluconate to the site immediately after the rinse. The antidote will begin to draw the fluoride ions out of the skin, so prompt application is imperative.
  - Seek immediate medical attention. All cases of HF exposure require medical attention. Assistance can be provided by the lab manager or any lab safety person.
  - If you inhale fumes, seek medical attention immediately.

- **HF Spills:**
  - You must wear Silver Shield gloves and a plastic apron when managing an HF spill.
  - For spills within the hood or small amounts outside the hood, wipe up the spill with disposable toweling, such as Kimwipes, that is more absorbent than clean-room wipes. Isolate any disposable materials that come or may have come into contact the HF from normal trash by placing them in a plastic bag labeled with a EH&S Hazardous Material/Waste tag. Let the lab manager know about the spill because the deck plate in the bench may need to be removed to clean the lower catch basin.
  - Large spills outside the hood require evacuation of the clean room. Immediately notify the lab manager of the situation so that hazmat procedures can be implemented.

**Piranha Solution**

Acid piranha solution is a solution of sulfuric acid and hydrogen peroxide. It is used primarily as a glass and sapphire substrate cleaner. Occasionally it is used as an etchant. Piranha is one component of a two-part high-explosive that is unstable above 10° C. As a strong oxidizer, it is important to keep organic solvents away from it. In a chemistry lab at Cornell, circa 1986, piranha solution aspirated into a tape-wrapped glass flask containing only a trace amount of acetone caused an explosion that hospitalized and permanently impaired a graduate student with lacerations to the face, hands and arms. A chemist at the scene estimated the force of the blast to be equivalent to a quarter of a stick of dynamite.

- **Protocol for using piranha solution:**
  - Although oxygen and carbon dioxide are the only two gases evolved from piranha solution, small amounts of sulfuric acid may be aerosolized and cause irritation to skin and mucous membranes.
Avoid the fumes by using piranha solution only in the hood with the sash down. Wear a double set of latex or nitrile gloves. A plastic apron is also recommended.

- Familiarize yourself with the properties and cautions of sulfuric acid, the main component of piranha solution, by reading the MSDS.
- Do as much pre-cleaning of the substrate as possible, including stripping any resists with acetone or an oxygen plasma before introducing it to the piranha solution. Do not immerse a hydrocarbon-coated object directly into the solution. If it doesn’t blow up, it will certainly boil over.
- Make sure there are no organic solvents in the immediate vicinity of the location where the solution will be made and used.
- Make only as much as piranha solution as you think you might need. The shelf life of this material is on the order of days.
- Slowly pour the hydrogen peroxide into the sulfuric acid. The solution gets very hot remarkably fast; one can easily exceed its safe operating temperature just in the mixing process.
- Use only fluoropolymer utensils, such as Teflon, for manipulating the substrate in the solution. Piranha readily corrodes most metals.
- The action of piranha is optimal at 100 °C. Do not exceed this temperature.
- Immerse objects slowly into the solution to prevent thermal shock and to get a feel for the interaction of the two materials.
- When finished, allow the solution to cool before pouring it into a properly labeled and clean Nalgene container or a container already labeled for piranha storage. Because oxygen is continuously dissociating from the peroxide, use only a cap that is vented, or the bottle will burst within a few hours.
- Immediately place the storage container in the peroxides storage box.
- Piranha has to be aspirated and neutralized before disposal. Do not leave active piranha solution out for disposal. In some cases, depleted solution can be replenished.

Heated piranha will dissolve rubber gloves in seconds. If any should splash or spill on the gloves, quickly remove them and place in the sink for neutralizing and rinsing later. Thoroughly rinse your hand at the site, just in case some solution penetrated.

- Splashed or spilled piranha on cloth will be evident as black spots. By the time the solution has reacted with the natural or synthetic fibers of clothing, the peroxide has been depleted and the temperature mitigated to a safer level. However, the sulfuric acid is still an issue of concern.
- Contact with skin will be immediately apparent. Flush the contact area with water for at least 15 minutes while removing any affected clothing. Excessive acid on skin can be neutralized with a 2% solution of bicarbonate of soda (baking soda) located in the grey “Used Chemicals” cabinet. Medical attention may be required if the exposure is severe.
- If contact with the eyes should occur, immediately flush the eyes with a gentle but large stream of water for at least 15 minutes, lifting lower and upper eyelids occasionally, using the eye washer between the acid and HF benches. Irrigate the eye with the sterile, isotonic solution located just above the washer. Call a physician at the Wardenburg Health Center immediately.

Wear Silver Shield gloves when managing a sulfuric acid spill.
- Slowly neutralize the spill with bicarbonate of soda.
- Wipe spill with absorbent cleanroom wipes and rinse the wipes in the sink before bagging them and disposing of them in the trash.

After you have finished reviewing the Clean Room Safety Module please see Cindy Torres, JILA Reception to complete the Clean Room quiz in the Quiz Packet.
**Introduction**

Safety procedures in the JILA Staff Shop must be followed to ensure the safety of you and your co-workers and to maintain your freedom to use the shops at any time.

Shop users must maintain proper respect for all machine tools. Hand and machine tools are extremely dangerous if used improperly or carelessly. For example, a band saw is a particularly unforgiving device if used improperly; butcher shops use band saws to cut meat and bone.

Every JILAn who wants to use the staff shop must have appropriate training, we are happy to provide one-on-one assistance for smaller jobs but request that the shop class be taken before undertaking more ambitious projects.

The shop class is a very good basic overview of machine tool techniques and shop safety and is offered twice a year in June and October. The shop class is not required, however, we do encourage you to take it, no matter what your previous experience is. The class is an excellent way to meet the shop staff, to learn all of the tools and equipment available to you and to get a good look at the capabilities of the instrument shop in general.

JILAns have more freedom to use shop tools and machines than most scientists elsewhere. At most universities, shop classes and testing are required, and shop access is limited. A serious shop accident will impact research progress in the JILA labs as graduate students and postdocs would lose the freedom to make experimental equipment nights and on the weekends. By reading this safety module and passing the quiz, you will not only be making a personal commitment to keep the staff shop accessible and open 24/7, but also helping protect yourself and your colleagues from serious injury.

Always keep in mind that the Instrument Shop Staff is here to help you and that we want you to ask questions.

**Safe Work Habits**

Machine shop safety starts with personal responsibility for safe work habits. Working in the shop when you are tired or in a hurry often results in ruined parts, damaged tools, or, worst of all, personal injury.

Working in the shop alone after hours is also never a good idea, you should always have someone available to assist you if you should lose consciousness or become tangled in a machine. This did happen in another institution and the results were not good.

Also, never work in the shop when intoxicated or taking prescription medications that warn against driving or using machinery.
Safe Shop Attire

- **Clothing.** No loose clothing is permitted in the shop. Long hair should be tied back since it can get tangled in rotating machinery, causing your hair and scalp to be ripped out. Before using machines, remove jewelry such as rings and wrist watches. NEVER wear gloves or use rags close to moving parts. Rags, gloves, and loose clothing can easily get tangled up with moving parts and pulled into a machine, bringing your hands and fingers along with them.

- **Safety glasses.** Wearing safety glasses is MANDATORY AT ALL TIMES in the staff shop. No exceptions, not even if you already wear glasses. The shop staff provides special “over-glasses” safety glasses. Keep in mind:
  - you or the person across the room could shatter something that ends up hitting you in the eye, and
  - polycarbonate safety glasses have side shields that provide protection against splashed chemicals.
  - The moment you walk into the shop, put on safety glasses.

- **Shoes.** Open-toed shoes are not permitted in the staff shop since they do not provide adequate protection against sharp metal chips.

Tools and Machines

Shop machines are powerful, and safety precautions must be taken to avoid injury. For example, always use a push stick when cutting small parts on a band saw; if you lose control, the stick gets cut and not your hand.

Several different objects can unexpectedly fly out of machines: cutting tools, sharp metal fragments, and even your work piece. In general, these flying objects are sharp and dangerous. Every machine has specific hazards, so it is crucial to talk to the shop staff before using an unfamiliar machine.

Here some of the most important safe work rules:

- Report any broken or malfunctioning equipment to shop staff immediately. DO NOT attempt to repair equipment yourself.
- BE CAREFUL working with thin sheet metal in a drill press. Clamp your work piece down well. Do not hold the work down with your hand, as the drill can rotate the work piece, slicing your hand badly.
- Improper clamping in a drill press can result in a part leaving the table and getting flung around like a rotating knife, which can cut off your fingers or your hand. The drill can also grab your work piece out of your hand and slice it up.
- When using a lathe or milling machine, firmly secure your work piece and any devices needed to hold it. Any of these objects can fly off and hurt you. Most accidents with a lathe happen when someone gets their hands too close to the spinning parts. With a milling machine, tool bits can shatter and parts can be ejected by the machine.
- Stop a lathe if a ribbon of chips starts wadding up and rotating with the machine. A spinning wad or ribbon of chips poses a serious hand-cutting hazard. These chip ribbons should NEVER be removed by hand. Stop the machine and use a pair of pliers.
Good Housekeeping

Good housekeeping is essential for a safe and efficient work environment in the shop. It is important not to let tools and parts clutter machine tables. Slippery oil spills should be cleaned immediately, and piles of sharp metal chips should also be removed. Tools and parts should not be left in the middle of the floor as they pose a tripping hazard.

Fire Prevention

When using gas torches, or welding and soldering equipment, your number one risk is starting a fire. Pay attention to your surroundings and keep all heat sources safely away from flammable materials. For instance:

- When soldering, do not point the torch at anything other than your work piece.
- Do not solder or weld near flammable materials. Use flame shields.
- Gas torches are inherently dangerous. You can easily burn yourself or ignite nearby materials.

Chemical Safety

Flammable solvents, including alcohol, acetone, and kerosene, are used for cleaning in the instrument shop. Getting any of these solvents near something hot could easily start a fire.

Chemical containers must always be labeled with the substance name, concentration (if applicable), and date. In addition, proper safety precautions should be used during handling of chemicals, including appropriate storage, disposal, and the use of safety equipment such as rubber gloves.

Emergency Call System

There is an emergency call button located on the entry door next to the sink where you will also find a wearable remote button. The remote should be worn in a safe place that you can easily reach on your shop coat.

This system will not dial 911, it is there to use if you are unable to reach the phone and will put you in contact with an operator who will assess the situation and send for emergency help.

911 should always be the preferred option.

Keep in mind that no matter which system you use, it still requires a significant amount of time for emergency personnel to arrive and neither system should be thought of as a safe alternative to having someone close by to assist you.

Thank you for reading the instrument shop safety module.
We look forward to seeing you in our next shop class.

After you have finished reviewing Machine Shop Safety Module please see Cindy Torres, JILA Reception to complete the machine-shop quiz in the Quiz Packet.