COMMON HAZARDS IN THE SCHOOL LABORATORY

Accidents in the laboratory are often the result of carelessness or ignorance either by you or by your neighbors. The safety precautions outlined below will be worthless unless you plan, understand, and think through the consequences of every operation before you perform it. The common accidents, which often occur simultaneously, are: fire, explosion, chemical and thermal burns, cuts from broken glass tubing and thermometers, absorption of toxic, but non-corrosive chemicals through the skin, and inhalation of toxic fumes. Less common, but obviously dangerous, is the ingestion of a toxic chemical. Each of these types of hazards are discussed in a general way below:

1. **FIRE:** Be aware of all of the types of situations that can generate a fire.
2. **EXPLOSION**: Never heat a closed system or conduct a reaction in a closed system (unless specifically directed to perform the latter process and then only with frequent venting). Before starting a distillation or a chemical reaction, make sure that the system is vented. The results of an explosion are flying glass and spattered chemicals, usually both hot and corrosive.
3. **CHEMICAL BURNS:** Many inorganic chemicals such as the mineral acids and alkalis are corrosive to the skin and eyes. Likewise, many organic chemicals, such as acid halides, phenols, and so forth are corrosive and often toxic. If these are spilled on the desk, in the hood, or on a shelf, call for assistance in cleaning them up.
4. **THERMAL BURNS**: from heat or chemical reactions generating heat.
5. **CUTS**: The most common laboratory accident is probably the cut received while attempting to force a cork or rubber stopper onto a piece of glass tubing, a thermometer, or the side-arm of a distilling flask. Be sure to make a proper-sized hole, lubricate the cork or stopper (lubrication is essential with a rubber stopper), and use a gentle pressure with rotation on the glass part. Severed nerves and tendons are common results of injuries caused by improper manipulation of glass tubes and thermometers. Always pull rather than push on the glass when possible.
6. **ABSORPTION OF CHEMICALS**. Keep chemicals off the skin. Many organic substances are not corrosive, do not burn the skin, or seem to have any serious effects. They are, however, absorbed through the skin, sometimes with dire consequences. Others will give a serious allergic reaction upon repeated exposure, as evidenced by severe dermatitis. Be careful about touching your face or eyes in the lab; make sure your hands are clean first. Gloves should always be available in the lab. However, gloves provide only a temporary layer of protection against chemicals on your skin and may be permeable to some chemical reagents, without visible

deterioration. If your gloves come in contact with a chemical reagent, remove them, wash your hands, and get a new pair immediately.

7. **INHALATION OF CHEMICALS**: Keep your nose away from chemicals. Many of the common solvents are extremely toxic if inhaled in any quantity or over a period of time. Do not evaporate excess solvents in the laboratory; use the hood or a suitable distillation apparatus with a condenser. Some compounds, such as acetyl chloride, will severely irritate membranes in your eyes, nose, throat, and lungs, while others, such as benzyl chloride, are severe lachrymators, i.e. they induce eye irritation and tears. When in doubt, use the hood.

8. **INGESTION OF CHEMICALS**: The common ways of accidentally ingesting harmful chemicals are: (1) by pipet, (2) from dirty hands, (3) contaminated food or drink and (4) food use of chemicals taken from the laboratory. Below are ways to avoid accidental ingestion of chemical reagents.

9. **SLIPS / TRIPS & FALLS**: Many injuries stem from poor housekeeping. Slips, trips, and falls are very common but easily avoided. Start with safe and organized storage areas. Material storage should not create hazards. Bags, containers, bundles, etc., stored in tiers should be stacked, blocked, interlocked, and limited in height so that they are stable and secure against sliding or collapse. Keep storage areas free from an accumulation of materials that could cause tripping, fire, explosion, or pest harborage.

10. **CHEMICAL HAZARDS**: Use of acids / bases / solvents that generate fumes, burns, penetrate the skin barrier, spills, etc.

11. **BIOLOGICAL HAZARDS**: Use of bacteria, viruses, human or animal blood /tissue / bodily fluids can carry disease.

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HAZARDS ASSOCIATED WITH EQUIPMENT / EXPERIMENTS:

1. AUTOCLAVES - Autoclaves present a number of physical hazards such as:

- ☐ **Heat,**
- ☐ **Steam**
- ☐ **Pressure**,
- ☐ **Thermal burns** from steam and hot liquids.
- ☐ **Cuts** from broken or exploding glass.

2. BATTERIES:

- ☐ Lead acid batteries contain **corrosive liquids** and also generate **hydrogen gas** during charging which poses an explosion hazard.
- ☐ There must be adequate ventilation to prevent **hydrogen build up** and an eyewash/safety shower in battery charging locations.
- ☐ Lithium batteries may burst into **flames** if overcharged,
- ☐ Nickel cadmium and lead acid types contain **heavy metals**.
- ☐ Almost all rechargeable batteries are capable of sufficient output current to **start fires if short-circuited.**

3. CENTRIFUGES:

- ☐ Be familiar with the operating procedures written by the manufacturer.
- ☐ Pay careful attention to instructions on balancing samples -- tolerances for balancing are often very restricted. **Unbalanced samples** can cause the centrifuge to jam or cause the samples to blow the lid and become air born.
- ☐ Check the condition of tubes and bottles, to prevent **breakages / spills** during centrifugation.
- ☐ Whenever centrifuging biohazardous material, always load and unload the centrifuge rotor in a biological safety cabinet to prevent **exposure to the material**
- ☐ Avoid pop-top tubes which can **create aerosols** upon opening. Use screw capped tubes instead.
- ☐ Ensure the lid to the rotor door is properly sealed to prevent **spills**.

4. ELECTRICAL SAFETY:

- ☐ **Wet hands, salt solutions, and some anti-static devices** may enhance electrical contact with the body.
- ☐ **Shock hazards**.
- ☐ **Corrosive**s found in the laboratory environment may deteriorate wiring or insulation.
- ☐ Many electrical devices are also potential **ignition sources**.
- ☐ Never store **flammable liquids** such as solvents or fuels near electrical equipment, even temporarily.
- ☐ Use extra caution and ground fault circuit interrupter (GFCI) devices when these

conditions exist.

- ☐ Remove **rings, watches and other jewelry** which may become part of an electrical circuit when working around electricity.

5. ELECTROPHORESIS EQUIPMENT:

- ☐ Electrophoresis units present several possible hazards including **electrical, chemical, and radiological hazards.**
- ☐ Electrophoresis units use very **high voltage** (up to 2000 volts) and potentially hazardous current (80 milliamps or more). This high power output has the potential to cause a fatal electrical shock if not properly handled.
- ☐ Buffer tanks can have **cracks or leaks, exposed connectors, or missing covers**. If your units have such hazards, replace them or perform necessary retrofitting before use.

6. EXTRACTION, DISTILLATION, AND EVAPORATION:

Some routine laboratory operations have physical hazards that can be avoided by good technique. Here are some guidelines to prevent common mishaps:

A. EXTRACTIONS USING A SEPARATOR FUNNEL

- **Over pressurization** - could cause the vessel to burst
- **Mix volatile solvents** - by swirling the solution and vented repeatedly to reduce pressure before separation.
- **Flying stopcock** - When opening the stopcock, your hand should keep the plug firmly in place.
- **Fires / hazardous fumes** - Vent funnels away from ignition sources and people, preferably into a hood.
- **Overexposure to fumes** - Keep volumes small to reduce the risk of overpressure; if large volumes are needed, break them up into smaller batches.

B. DISTILLATIONS

- **Bumping / Splashes** - Avoid sudden boiling since the force can break apart the apparatus and result in splashes. Bumping can be avoided by even heating, such as using a heat mantle or boiling chips. Also, stirring can prevent bumping. Boiling stones can be used only if the process is at atmospheric pressure.
- **Boiling over** - Do not add solid items such as boiling stones to liquid that is near boiling since it may result in the liquid boiling over spontaneously.
- **Explosions** - Organic compounds should never be allowed to boil to dryness unless they are known to be free of peroxides, which can result in an explosion hazard when concentrated.

C. Reduced pressure distillation and rotary evaporation

- **Overheating** - Do not overheat the liquid. Superheating can result in decomposition and uncontrolled reactions.
- **Superheating and bumping** - often occur at reduced pressures so it is especially important to abide by the previous point on bumping and to ensure even, controlled heating

7. GENERAL EQUIPMENT SET UP:

☐ **Cluttered workspace** - Keep your work space free of clutter.

☐ **Falling apparatus** - Set up clean, dry apparatus, firmly clamped and well back from the edge of the lab bench making adequate space between your apparatus and others work. Choose sizes that can properly accommodate the operation to be performed. As a rule, leave about 20% free space around your work.

☐ **Spilled liquids** - A properly placed pan under a reaction vessel or container will act as secondary containment to confine spilled liquids in the event of glass breakage.

☐ **Fires** - When working with flammable gases or liquids, do not allow burners or other ignition sources in the vicinity. If a hot plate is used, ensure the temperatures of all exposed surfaces are less than the auto ignition temperature of the chemicals likely to be released and that the temperature control device and the stirring / ventilation motor (if present) do not spark.

☐ **Fires** - Whenever possible, use controlled electrical heaters or steam in place of gas burners.

☐ **Falling apparatus** - Addition and separator funnels should be properly supported and oriented so that the stopcock will not be loosened by gravity. A retainer ring should be used on the stopcock plug. Glass stopcocks should be freshly lubricated. Teflon stopcocks should not be lubricated.

☐ **Falling apparatus** - Apparatus attached to a ring stand should be positioned so that the center of gravity of the system is over the base and not to one side. There should be adequate provision for removing burners or baths quickly. Stands bearing heavy loads should be firmly attached to the bench top. Equipment racks should be securely anchored at the top and bottom.

☐ **Trip hazards** - Apparatus, equipment, or chemical bottles should not be placed on the floor. If necessary, keep these items under tables and out of aisle ways to prevent creating a tripping hazard.

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- ☐ **Explosion hazards** - Never heat a tightly closed container. Provide a vent as part of the apparatus for chemicals that are to be heated. Prior to heating a liquid, place boiling stones in unstirred vessels (except test tubes). If a burner is used, distribute the heat with a ceramic-centered wire gauze. Use the thermometer with its bulb in the boiling liquid if there is the possibility of a dangerous exothermic decomposition as in some distillations. This will provide a warning and may allow time to remove the heat and apply external cooling. The setup should allow for fast removal of heat. A lab jack under the heating mantle is a good way to accomplish this.

- ☐ **Hazardous gases, vapors, dusts, or fumes** – whenever they are likely to be evolved, an appropriate sized local exhaust system or laboratory hood must be used. Most vapors have a density greater than air and will settle on a bench top or floor where they may flow to a distant burner or ignition source. These vapors will roll out over astonishingly long distances and, if flammable, an ignition can cause an explosion or fire.

- ☐ **Implode / explode hazards** - Consider using a hood when working with a system under reduced or positive pressure (which may implode or explode. Close the sash to provide a shield. If a hood is not available, use a standing shield. Shields that can be knocked over must be stabilized with weights or fasteners. Standing shields are preferably secured near the top. Proper eye and face protection must be worn even when using safety shields or laboratory hoods. Note that while hoods will provide some protection, they are not designed or expected to contain significant explosions.

8. GLASSWARE HANDLING, CLEANING AND DISPOSAL:

- ☐ **Broken glass / spills / leaks** - Glass containers of hazardous chemicals should be transported in rubber bottle carriers or buckets to protect them from breakage and contain any spills or leaks. It is recommended to transport plastic containers this way as well since they also can break or leak.

- ☐ **Spills / leaks / dropped items** - Plastic containers can deteriorate with time, typically becoming yellow and brittle. The process is accelerated by exposure to solvents, sunlight, and heat. Be particularly aware of hazardous chemicals stored for a long time in plastic bottles. Also, exercise caution with older plastic pails in which handles may break off, or bottoms crack.

- ☐ **Fires via static -** Some plastic containers generate static that can ignite flammable vapors. Avoid storing flammables in unapproved plastic containers.

- ☐ **Cuts / abrasions** – when handling glassware check for cracks and chips before using it. Damaged glassware must be repaired before use or disposed of.

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- ☐ **Pokes / cuts / broken glass** - Use care when inserting glass tubing into stoppers: use glass tubing that has been fire-polished, lubricate the glass, and protect your hands with heavy gloves.

- ☐ **Cuts** - All cut lab glass, including stir rods, should be fire polished before use. Unpolished tubing can cut skin, and inhibit insertion into stoppers by tearing the rubber.

- ☐ **Burns** - After polishing or bending glass, give ample time for it to cool before grasping it. **Cuts or pokes** – when inserting glass rods or tubing into stoppers, Lubricate the glass. Water may be sufficient, but glycerol is a better lubricant. Wear heavy gloves or wrap layers of cloth around the glass and protect the other hand by holding the hose or stopper with a layered cloth pad. Hold the glass not more than 5 cm from the end to be inserted.

- ☐ **Cuts / abrasions** – Disposal of broken glassware must be managed to prevent injury. Put other sharps such as pipette tips and razor blades or broken glass into puncture resistant containers before disposal. Normal sharps can then be placed into the regular trash. Glassware and sharps that are grossly contaminated with hazardous materials will be shipped with similarly contaminated lab trash.

9. HEAT AND HEATING DEVICES:

- ☐ **Burns or fire** – heating devices (devices that become hot or produce flame) should be set up on a sturdy fixture and away from any ignitable materials (such as flammable solvents or paper products and other combustibles). Do not leave open flames (Bunsen burners or alcohol lamps) unattended.

- ☐ **Electrical hazards** - Heating devices, and other electrical equipment, should not be installed near safety showers, eye washes, or other water spraying apparatus due to electrical shock concerns and potential splattering of hot water or breakage of hot glass.

- ☐ **Burns / fires** – Oven heat generated should be adequately removed from the area. Leave ample clearances around all sides of the oven.

- ☐ **Tipping over / spills** - Heating baths should be of sound construction and set up with firm support to prevent tipping.

- ☐ **Tripping hazards** - Route cords out of the way to further reduce the risk of tipping.

- ☐ **Fire / explosion** - Since combustible liquids are often used in heating baths, the thermostat should be set so the temperature never rises above the flash point of the liquid. Check the MSDS for the chemical to determine the flashpoint.

Compare that flashpoint with the expected temperature of the reaction to gauge risk of starting a fire.

10. MECHANICAL HAZARDS:

- ☐ **Rotating parts / pinch points** - Avoid wearing loose fitting clothing or necklaces that could be drawn into a rotating assembly. Ensure all parts are guarded.
- ☐ **Pinch points** - Do not brake moving parts by hand; wait for motion to stop on its own. Ensure all guards are in place.
- ☐ **Falling equipment** - Be aware of assemblies that vibrate and could "walk" into other objects or fall off a counter.
- ☐ **Pinch points** – belts, pulleys and other moving parts must be properly guarded. Do not remove guards unless the equipment has been locked out.

11. VACUUM HAZARDS:

- ☐ **Cuts / pokes / broken glass** - Inspect glassware that will be used for reduced pressure to make sure there are no defects such as chips or cracks that may compromise its integrity.
- ☐ **Flying glass -** Use a shield between the user and any glass under vacuum or wrap the glass with tape to contain any glass in the event of an implosion.
- ☐ **Pinch points -** Belts, pulleys, and other moving parts must be properly guarded.
- ☐ **Electrical hazards -** Follow appropriate lock-out procedures if you cannot directly unplug the device for maintenance. Pumps may start automatically.
- ☐ **Explosion hazards -** Connect pump inlet and outlet properly**.** Pump connections can look the same. Reversing the flow direction can pressurize your apparatus leading to an explosion. At minimum you will contaminate it with oil.

12. LIGHTING:

- ☐ **Poor lighting** - Lighting in laboratories must adequately illuminate all work areas (100-200 lumens). Contact Facilities via a work request if you have concerns about lighting levels or burned-out bulbs that need replacing.
- ☐ As an energy conservation measure, please remember to turn off your lights when you leave your lab.

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13. NOISE:

- ☐ **Noise** is the most common cause of hearing loss, and one of the most common occupational illnesses in the United States.

- ☐ **An explosion** of a small quantity of an unstable chemical (such as an azide or organic peroxide) experienced at close range, may permanently damage your hearing.

- ☐ **Repeated exposures** to loud machinery may, over an extended period of time, also damage your hearing.

- ☐ **Examples of noise** generating operations include machinery such as generators, compressors, blowers, pumps, mixers, and shakers; operation of cell sorters, sonicators, blenders, and grinders; and venting of high pressure gases.

- ☐ If a situation arises where a worker is frequently exposed to a noise sufficiently loud to require raising one's voice to be understood, it may be at a level that requires a more detailed analysis. Contact the S&H Officer to arrange for a noise survey.

14 CRYOGENS, DRY ICE, COMPRESSED GASES, AND PRESSURE HAZARDS:

- ☐ **Pressure build-up:** Dry ice sublimates continuously, and if it is confined in a gas tight container, it can build pressure until the container bursts. Dry ice must never be sealed in gas-tight containers.

- ☐ **Frost bite:** Skin contact with dry ice will result in frostbite/cryogenic burns. Protective insulated gloves or tongs must always be used when handling dry ice.

- ☐ **Oxygen deficiency:** If kept in an enclosed, poorly ventilated space (like a car with closed windows) the carbon dioxide evolved from dry ice can displace oxygen resulting in a suffocation hazard. Dry ice must only be kept in well ventilated areas.

- ☐ **Embrittlement:** Dry ice can render flexible materials brittle. To avoid cracks or other damage, keep bare dry ice off counter tops and away from electrical cords, tubing, fabrics, and other items that may be damaged by the extreme cold.

- ☐ **Explosion hazards** - Since oxygen in air has a higher boiling point than nitrogen, liquid oxygen can be produced and cause an explosion hazard. If liquid nitrogen is used, the chamber should be evacuated before charging the system with coolant.

- ☐ **Boiling & splashing** generally occur when charging (cooling) a warm container, so stand clear and wear appropriate protective equipment. Items should be added slowly and in small amounts to minimize splashing.

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- **Rupture** - A component may burst or break, releasing high pressure fluids or gases and flying debris. A catastrophic failure may also be accompanied by a shock wave which can cause damage some distance away. Causes of rupture include over-pressurization, corrosion, metal fatigue, over-heating, and faulty design or assembly.

- **Injection** - High pressure fluids can cut/penetrate the skin causing damage to tissues and toxic effects from the substance itself.

- **Atomization** - Materials with little flammability hazard, such as hydraulic oil, may become a profound fire hazard if released as a mist from a high pressure leak.

- **Auto-ignition** - Rapid compression can generate temperatures sufficiently high to ignite common materials like plastics, oils, and greases. Systems using oxygen, fluorine, or other oxidizing gases are particularly susceptible to auto-ignition and must be specially cleaned and certified to avoid this problem.