Chapter 1
Introduction
Purpose
The information in this publication is provided as technical assistance to Illinois public school districts in developing district policies regarding secondary school science laboratories. The information has been compiled by the Illinois State Board of Education as representative of appropriate practices for secondary school science laboratories. Except for the provisions of federal or Illinois laws or rules quotes, the content of this publication does not create requirements applicable to public school districts, nor is it presented as encompassing all appropriate practices. Districts should consider existing conditions, curricula and requirements, as well as other sources of guidance (some of which are referenced in this publication) in developing district policies.
Introduction
Everyone wants to have a pleasant and safe environment in which to work and learn. Safety is a very important concern in science courses because students are learning new skills, working with unfamiliar equipment in close quarters, and using materials that can pose some degree of hazard. This manual is intended to help teachers maintain a safe classroom environment for the teaching of science.
The initial version of this manual focuses on the handling of chemicals and standards for the chemistry laboratory. Later supplements are planned to include biology, physics, other natural science laboratories, and K-12 activities.
A version of this safety manual will be available on disk so that sections can be used and modified to fit local needs. The student safety rules, safety contract, safety audit, and chemical hygiene plan are sections that might be adapted for your school.

Top Ten Checklist for Teachers and School Administrators
I. Do you understand your professional responsibilities with regard to safety issues?
Current standards of the chemical and safety professions for the safe handling of chemicals and scientific equipment in laboratories are designed to protect teachers and students from harm (chapters 3,4,6,7,8,9). Accidents will occur during the course of laboratory work, but their frequency and the possibility of resulting injury can be minimized by knowledge and common sense. Following recommended practices is an important way of defending against any charges of negligence that might result from an accident (section 5.1).
II. Does your school have a written comprehensive safety plan?
A school needs to develop a comprehensive safety plan that addresses safety issues in all places where hazardous materials are used, such as science laboratories, art and shop classes, as well as building maintenance. Public schools in Illinois fall under the jurisdiction of the Illinois Department of Labor and work areas are covered either under the Worker Right-to-Know Law or the Laboratory Standard, but not by both. The chemical hygiene plan, required by Illinois law under the Laboratory Standard is an excellent step in developing this comprehensive safety (section 5.3.3 and chapter 12). Private and parochial schools fall under federal Occupational Safety and Health Administration (OSHA). A successful safety program requires participation by administration, teachers, other school employees, students, and the community.
III. Does your school have a functioning safety committee that has power to make

recommendations?

The administration should organize a safety committee to develop the safety plan and ensure that it is carried out. A high priority of the safety committee is to conduct and document regular safety inspections of all laboratories (sections 3.1 and 9.2) and to conduct regular safety audits to ensure that the necessary safety equipment is available and in working order (section 3.1).

IV. Do you have a set of safety rules that students, teachers, substitute teachers, parents, and administrators understand and practice?

The special activities in science classes require that students follow strict codes of behavior. A set of safety rules must be adopted by the science teacher and strictly enforced (section 4.2.1). A safety contract signed by both the student and a parent is recommended to document the training of the student and to enlist cooperation of parents in the safety program (section 4.2.2).

V. Do you regularly train students and staff in proper handling of equipment, chemicals, and emergency equipment?

Staff and students must be trained in the proper use of safety equipment (chapter 3) and in interpreting hazards of chemicals from the material safety data sheet (MSDS) (section 7.2). In addition to safety rules, students must be trained in the proper handling of laboratory equipment and chemicals (chapter 9). This training requires continual reinforcement and appropriate supervision.

VI. Do you know what to do when an emergency arises?

ecause accidents can happen even in the safest school, emergency procedures and training are essential components of the safety plan (chapter 4). An accident report form (section
4.1.5) that provides a written record of an accident is essential in case of later legal action. All incidents should be investigated and action taken to prevent similar incidents. Evacuation routes need to be planned and practiced (section 3.2.10). Procedures must be developed and practiced to handle fires and chemical spills (sections 3.2.4, 3.2.5). All incidents should be reported to the proper administrators.

VII. Do you have a strategy for minimizing exposure and disposal of hazardous materials?

Schools should look at strategies to minimize the amount of hazardous materials used in the laboratory (chapter 8). Switching to safer chemicals, adopting microscale techniques, and using multimedia technology are ways to reduce exposure to hazardous chemicals and minimize disposal problems.

VIII. Are hazardous materials stored properly?

Laboratory chemicals must be properly stored and labeled (section 7.5). A written inventory of the chemical storeroom(s) must be made (section 8.1.2). The list of material safety data sheets (MSDSs) maintained under the Worker Right-to-Know Law needs to be provided to the fire department, but the inventory of laboratory chemicals under the Laboratory Standard does not.

IX. Do you keep accurate records?

In case legal action results from an incident, it is important to document that students knew safety rules, were trained in correct safety procedures, and that safety equipment was available and in proper working order (chapters 3,4).

X. Do you follow consistent standards of practice in all classes?
Safety should be a school policy, not the policy of an individual teacher. Teachers, administrators, students, and parents should form the safety committee and develop uniform rules for conduct in science laboratories. Remember that many of these safety issues apply to fine arts and industrial arts classes and to custodians. Include representatives from these groups in the safety committee (chapters 6,7,8,9).

Acknowledgments:
The Illinois Science Safety Manual is a product of the Center on Scientific Literacy of the Illinois State Board of Education. This manual is intended to be a reference guide for the most common safety concerns encountered during secondary school science activities and is not meant to be an all-encompassing document.
This project was initiated by Gwen Pollock, Center on Scientific Literacy, Illinois State Board of Education. This manual was prepared by Gary Trammell, University of Illinois at Springfield; John E. Pingel, University of Illinois at Urbana-Champaign; John Fisher, Rend Lake Community College; Clarence Josefson, Millikin University; Mary Jackson, Springfield High School; Steven Vaughn, Belleville East High School; Susan Matthews, MacArthur High School, Decatur; and Elizabeth Ziebarth, Centennial High School, Champaign. Illustrations of laboratory techniques were prepared by Curt Neitzke, University of Illinois at Springfield.
We wish to thank the following individuals for their assistance in reviewing drafts of the manual and for offering valuable suggestions: James A. Coglianese, Forensic Scientist, Illinois State Police, Joliet; B/C Les Albert, Decatur Fire Department; J. Davidson, Batavia; Dr. Salim M. Diab, Department of Natural Sciences, College of St. Francis, Joliet; Illinois Educational Service Center Six, Chicago; Illinois Educational Service Center Eleven, Macomb; Illinois Educational Service Center Thirteen, Rantoul; Dr. Billy Fairless, Department of Chemistry, Southern Illinois University-Carbondale; Larry Flinn, Flinn Scientific Inc., Batavia; Ralph Foster, Illinois Environmental Protection Agency; Bill Gamora, member American Society of Safety Engineers-NE Illinois Chapter; William Haak, Lincoln Fire Chief, Lincoln City Fire Department, Lincoln; Gail Hermann, Quincy; Evalyn Holy, Willowbrook High School, Villa Park; Rick Schmitz, Center for Legal Studies, Sangamon State University; Science Department, Campaign Central High School, Champaign; Dr. Douglas Smith, Rockton; Mary Ellen Sronce, Laboratory Quality Specialist II, Illinois Department of Public Health; State of Illinois Environmental Protection Agency; State of Illinois Department of Nuclear Safety; Susan Steckel, North Greene High School; Joyce Stoelting, RN, Memorial Medical Center, Regional Burn Center, Springfield; Chief Greg Walters, Dr. Jed White, Department of Chemistry, Southern Illinois University-Edwardsville; David Winnett, Southern Illinois University-Edwardsville; Peoria Fire Department; Dr. Marie Wolff, IACT, Joliet Junior College; Bernadine Wysocki, Willowbrook High School, Villa Park.

Chapter 2
Responsibilities
Safety is a shared responsibility. A safe laboratory program requires participation by teachers, students, administrators, and the community.

2.1 Administrators' Responsibilities
1. Provide a safe and effective laboratory area for science activities
2. Provide safety items described in section 3.2 and ensure they are in good condition.
3. Provide regular inspections of the laboratory and document inspection and maintenance of safety equipment (section 3.1).
4. Develop a chemical hygiene plan (section 5.3.3; chapter 12).
5. Comply with Illinois Hazard Communication Standard (Right-to-Know Law) (section 5.3.2).
6. Comply with Illinois and federal regulations for disposal of chemicals (section 8.2).
7. Establish a school safety committee and ensure that it meets regularly (section 9.2).
8. Attempt to provide a class size appropriate to the laboratory and in keeping with recommendations of professional societies (section 3.3).

2.2 Teachers' Responsibilities
1. Set a good example by observing all safety rules, wearing proper protective equipment, and being enthusiastic about safety.
2. Know the properties and hazards associated with each material used in a laboratory activity before the students carry out the procedure.
3. Ensure that all safety equipment is present in the laboratory and is in good working condition (section 3.2).
4. Provide eye protection and other necessary personal protective equipment for students and instruct students in their use (section 3.2; chapter 6).
5. Before each laboratory experiment, instruct students about the hazards associated with each chemical and activity. Reemphasize the use of eye protection and other necessary personal protection equipment.
6. Ensure that all containers are properly labeled with their contents and hazards (section 7.5.6).
7. Make sure that all safety rules are obeyed (section 4.2.1).
8. Promptly clean up or direct the clean-up of spilled chemicals.
9. Dispose of chemical wastes properly (section 8.2).
10. Return chemicals to a locked storeroom after use.
11. Comply with the procedures in the school chemical hygiene plan (section 5.3.3; chapter 12).
12. Report any accidents or unsafe conditions in writing to your department chairperson, principal, or other appropriate administrator (section 4.1.5; 5.4).

2.3 Students' Responsibilities
1. Understand the experimental procedure before starting to work in the laboratory.
2. Be familiar with the properties and hazards of the chemicals you are working with.
3. Obey all safety rules and regulations and sign a safety contract.
4. Know location and use of all safety equipment in the laboratory.

5. Clean your work area immediately after use. Obey good housekeeping practices.

2.4 Parents' Responsibilities

1. Read the laboratory safety rules. Discuss these rules with your child. Sign the safety contract indicating that you have read and understood the safety rules.
2. Work with the teachers and administration at your school to develop a strong safety program.

Chapter 3
Physical Layout of the Laboratory
3. 1 Safety Audit and Safety Inspections

An important tool for maintaining a safe environment in the science laboratory is a safety audit. A safety audit ensures that the necessary safety items are available and in proper working condition. A safety audit is also an important planning tool. If it reveals deficiencies in safety equipment, a prioritized list of needed safety items or modifications in the physical layout can be prepared and budgeted. Such an audit helps the school in meeting requirements of the chemical hygiene plan (chapter 12) and in defending a teacher against allegations of negligence (section 5.1). The safety audit checks for the availability of safety equipment such as eyewash fountains and fire extinguishers, personal protective equipment such as chemical splash goggles (section 6.4.1), physical features of the room such as master cut-off controls for water, gas, and electricity, and proper storage of chemicals. Frequent safety inspections, typically every three months, are needed to ensure safety equipment is ready in case of an emergency. The safety audit and safety inspections should be under the control of the school safety committee (section 9.2). Copies of the safety audit and safety inspections should be maintained as permanent records of the school.

An example of a safety audit is included below. More detailed discussion of these items will be found later in this manual. Please refer to these sections for more specific criteria. In many cases, the criteria may be defined by the school district.

Sample Safety Audit

School: ____

Room: _____________ Area: _______________ Location: _______________

Teacher: ____

Grade level of students: ________ Type of Use: _______________________

This list is to be used as a means of identifying certain desirable features and fixtures as well as hazardous conditions that may exist in laboratories. More specific details regarding these items can be obtained in this guidebook and in the references cited.

Interior Layout of Room Section in Guidebook

Yes No

Are interior circulation paths adequate?

Are aisles and work areas free from clutter? 3.2.10

Is the room handicapped accessible? 3.2.11

Is there an adequate number of paths of travel leading to the outside of the building?

Do the exit door(s) open in the direction of the path of exit travel?

Policy and Procedures Section in Guidebook

Yes No

Are there school or district policies requiring inspections? 9.2

Are there requirements for reporting malfunctions?

Are all emergency procedures for fire, spills, and evacuation posted and highly visible? 4.1.3

Have emergency procedures for fire, spills, and evacuation been practiced with students?

Have you received proper training for the appropriate use of the type(s) of fire extinguishers in the lab?

3.2.4

Are local (room) cut-off controls and outlets for water, gas and electricity readily accessible, properly labeled and easily distinguished?
3.2.8
Is there an emergency communication system available from the classroom?
Are waste chemicals and waste solvent containers capped and clearly labeled with their contents?
Does mercury containing apparatus have a catch pan or other secondary container?
9.1.4
Fixtures, Equipment and Furnishings Section in Guidebook
Yes No Comments
Are eyewash fountains clearly labeled and have they been checked for proper operation?
3.2.2
Is the safety shower or drench hose clearly labeled and accessible from any part of the room in 10 seconds?
3.2.3
Are fire extinguishers clearly labeled and accessible from any part of the room within 10 seconds?
3.2.4
Does the fume hood have adequate air flow? Is it kept clean and not used to store chemicals? Is electrical equipment that may provide sparks such as variable transformers and power strips not located in hoods where flammable liquids are used?
3.2.9
Are fire blankets available, clearly labeled, and mounted for easy reach from the floor?
3.2.5
Is the first-aid kit adequately stocked 3.2.6
Are spill kits for acids, bases, flammable solvents, and mercury available, clearly marked and accessible?
Are special waste receptacles for broken glass and other sharp objects available and clearly labeled? Is the heavy plastic or ceramic container lined with a very tough plastic bag so custodians can remove the liner without handling the broken glass?
9.1.1
Are all pieces of equipment in proper working order or clearly marked "out of service" for repair?
Are all cords on electrical equipment in good condition?
Are belt guards present and properly functioning?
Are table tops or other work surfaces made of nonflammable, chemical resistant material?
Personal protective equipment Yes No
Are approved safety goggles available for each student and for visitors?
6.4.1
Is there a means of sanitizing safety goggles between usage?
3.2.1
Are protective gloves available that are appropriate for the chemicals being used?
6.4.2
Are there lab aprons available? 6.2
Are there beaker and crucible tongs available for handling hot glassware?

9.1.1
Are there suction bulbs available for pipetting? 9.1.5
Electrical and Ventilation Systems Yes No
Are there a sufficient number of appropriate kinds of electrical outlets in the appropriate locations?
Is the room lighting adequate?
Is the room ventilation adequate with at least 4 air exchanges per hour?
3.2.9
Is there an exhaust or purge fan available? 3.2.9
Is there a fire detection system?
Chemical Storeroom Section in Guidebook
Yes No Comments Guidebook
Can the storeroom can be locked and access restricted? 7.5.1
Does the storeroom have a smoke alarm?
Are there are fire resistant cabinets for flammable solvents?
7.5.1.1
Is the chemical refrigerator explosion proof and labeled "**No Food**"?
7.5.5
Is chemical shelving secured to the wall or floor? 7.5.1
Do the shelves have lips to prevent bottles from sliding off?
7.5.1
Is there adequate ventilation? 3.2.9
Are chemicals stored according to their chemical properties with color coded labels used to identify compatible chemicals?
7.5.1
Are acids stored in corrosion-resistant cabinets? 7.5.1
Is an ABC fire extinguisher available and have you been trained to use it?
3.2.4
Are protective leakproof containers available for transporting corrosive chemicals?
7.5.1
Is an inventory of chemicals in the storeroom available and has it been updated annually?
8.1.2
Are peroxide-forming chemicals marked with the date opened and tested for peroxides every 6 months or disposed of?
7.4.7
Are glass containers stored in a location where there is little chance breakage will occur?
7.5.1
Are gas cylinders firmly secured? 7.5.4
Are waste-chemical and waste-solvent containers are capped and clearly labeled with their contents and the word "**WASTE**"?
Are all containers of chemicals clearly labeled with the name of chemical, appropriate hazard warning, name of manufacturer or responsible party? Does the label on prepared solutions include the date mixed and the name of preparer?
7.5.6
Sample Safety Inspection
School: ____________________

Room: ______________________
Inspector: ___________________
Date: _______________________

Check for proper operation of: Satisfactory Unsatisfactory Date Remedied
Eyewash fountain
Safety shower
Fume hood
Auxiliary ventilation

Condition of: Satisfactory Unsatisfactory Date Remedied
Fire extinguishers
Fire blanket
First-aid kit
Spill clean-up kits

Hazards Satisfactory Unsatisfactory Date Remedied
Exits are not blocked.
Aisles are not cluttered.
Chemicals are not stored in room.
Glassware is not cracked or broken.
Chemicals are properly labeled.

Housekeeping Satisfactory Unsatisfactory Date Remedied
Sinks and sink traps
Fume hood
Work counter tops
Table tops
Floors
No food or drink
Broken glass container
Waste containers for chemicals

This safety inspection should be repeated every three months.

3.2 Use and Maintenance of Safety Items that Should be Available in All Laboratories

All of the safety equipment should be clearly labeled for easy location.. Safety equipment must be inspected regularly, typically every three months, and these inspections recorded. All faculty and students using the laboratory must be trained in the use of safety equipment.

3.2.1 Sanitation of Safety Goggles

If safety glasses and goggles are used by multiple students, it is important to sanitize them between each student use. Ultraviolet (UV) cabinets that hold up to 30 goggles and take from 5 to 15 minutes for a sterilization cycle are commercially available. A lower cost, but less convenient, alternative is to use a chemical disinfectant. Commercial goggle and facemask disinfectant cleaners are available in packets from goggle distributors. Household bleach and disinfectants can be used by diluting to the strength recommended on the label. Dip the goggles in the disinfectant solution and allow to air dry. Goggles are easily scratched and should not be wiped with cloth or paper towels. Products that contain alcohol dry faster but may adversely affect some plastics. If alcohol is used for disinfection, commercial alcohol wipes available from local drug stores may be used. Be sure to test your goggles with alcohol to make sure the plastic is not damaged.

3.2.2 Eyewash Fountains

Eyewash fountains are essential in any area when chemicals are used. Caustic chemicals can damage the eye within seconds of contact. John Brodemus has described a demonstration using cow eyes to illustrate the rapid damage of corrosive solutions to the eye. 1 If someone gets foreign material in the eye, the person must reach the eyewash in a few seconds. The American National Standards Institute (ANSI) requires that an eyewash be reached within 10 seconds and be within 100 feet of the hazard. Within the 7ANSI Z358.1-1990 standard is the recommendation that the time required to reach an eyewash should be determined by the hazard. For strong acids or strong caustic chemicals, the eyewash should be located immediately adjacent or within 10 feet of the hazard (ANSI Z.358.1-1990 E 7.4.4). 2

An eyewash fountain should:

- Treat both eyes simultaneously
- Provide a gentle flow of water for at least 15 minutes
- Be accessible within 10 seconds from the time of injury
- Leave both hands free to hold eyelids open
- Be accessible for all students

A plumbed eyewash fountain is best. A hand-held spray which can be a commercial model or a faucet shower attachment sold at local retail stores may supplement but not replace, a plumbed eyewash. This attachment must be modified by cutting off the faucet attachment and inserting the tubing over a laboratory sink faucet outlet. 3 Portable eyewash squeeze bottles are not an acceptable alternative because they can treat only one eye, provide an inadequate supply of water, are susceptible to contamination, and provide a good environment for the growth of microorganisms.

The National Safety Council recommends that all plumbed eyewash fountains be flushed for three minutes a week to reduce the risk of eye infections. All maintenance should be recorded. 4

Use of Eyewash Fountains 5

1. Begin washing the face, eyelids, and eyes for at least 15 minutes as soon as possible. The eyelids should be held open and the eyes rotated as much as possible to ensure removal of the chemical.
2. If the student is wearing contact lenses, the lenses should be removed immediately if at all possible. Continue flushing even if contacts cannot be removed.
3. If the student is lying down, gently hold the eyelids open and pour water from the inner corner of the eye outward. Do not allow the chemical to run into the other eye.
4. In the case of an alkaline burn or any other serious eye injury, immediately send for an ambulance so that first aid will not have to be discontinued during transport to medical facilities

3.2.3 Safety Showers

A safety shower must be available in each laboratory. The safety shower is used to wash hazardous chemicals from the skin and may be used on clothing fires. The Emergency Eyewash and Shower Equipment Standard (ANSI. Z, 358.1-1990) requires that an emergency shower should be located no more than 10 seconds in time nor greater than 100 feet in distance from the site of the emergency. The ANSI recommendation is that the maximum time to reach the shower should be determined by the potential effects of the chemicals being used. For strong acid and strong caustic chemicals, safety showers should be located within 10 to 20 feet of the hazard (ANSI Z.358.1-1990 E4.6.1). 2 The shower should be labeled, easily accessible, and free from obstructions. Deluge showers should provide uninterrupted flow of water until the valve is intentionally closed. Deluge showers are intended for major spills. A floor drain is a useful feature, but its absence should not prevent installation of a safety shower. The mess can be tolerated on the rare times the shower is used; however, care should be taken to avoid shock from contact with electrical equipment and the water that collects on the floor. Anti-slip floor mats may be provided. The shower should be tested on a regular basis and a record kept. A hand-held water sprayer with a 6-foot hose is a good alternative for small spills such as usually occur in the teaching laboratory. The hand-held spray can be directed to the affected part of the body and can also function as an eye wash. 3 This drench hose is a supplement, not a replacement for a plumbed safety shower.

1. Begin use of the shower as soon as possible, removing any contaminated clothing while in the shower (the fire blanket may be used for privacy).
2. The victim should remain in the shower for a minimum of 15 minutes, washing the skin with water or with soap and water for some organic chemical splashes. The water temperature should not be at extremes which might discourage the use of the shower. Precautions should be taken to protect the user from frigid conditions.
3. Avoid use of neutralizing solutions unless recommended by medical personnel.

3.2.4 Fire Extinguishers

In the event of a fire, you must decide if you can fight the fire or should evacuate the building and leave the job for professionals.. Most laboratory fires are small fires that can be extinguished easily without calling the fire department. However, even small fires can spread very quickly and become major fires. It may be better to call the fire department and evacuate the building even if someone is fighting a small fire, since any lost response time can make the difference between a lab fire and a building fire. The first few minutes can be critical. The decision whether or not to fight a fire will depend on the size and location of the fire and your comfort level in dealing with the situation. The safety of you and your students, not school property, is the first priority.

In case of a fire, the following course of actions have been recommended: 6, 7

- Alert other people in the laboratory and send for assistance. Never attempt to fight a fire alone.
- A fire contained in a small vessel can usually be suffocated by covering the vessel with a watch glass or inverted beaker.
- A clothing fire should be extinguished by using the stop, drop, and roll procedure or smothering with water or a fire blanket. **Fire extinguishers are not to be used on people**.
- In case of a serious fire, evacuate everyone except those persons trained to fight fires.
- Sound the fire alarm and call the fire department.
- Shut off master gas and electrical power.
- Close windows and doors if possible.

- If the fire is spreading or could block your escape route, leave immediately and leave the job to professionals.

If you choose to fight the fire, make sure you are using the correct fire extinguisher.
There are 4 classes of fires:
Class A - wood, paper, plastic, cloth
Class B - flammable liquids
Class C - electrical
Class D - combustible metals (Na, K, Mg, etc.)
Water is useful **only** for Class A fires, the common trash-can fire, and should **never** be used with Class B, C, or D fires. Multipurpose Class ABC dry chemical fire extinguishers contain monoammonium phosphate and are recommended for use in all classrooms. However, powder from dry chemical extinguishers may rapidly enter computers and cause permanent damage. CO2 fire extinguishers are recommended in labs where computers are present. Small combustible metal fires can be extinguished using dry sand. Special Class D fire extinguishers are available and are recommended if you use combustible metals such as magnesium, sodium, or potassium in experiments or demonstrations. Do not use CO2 fire extinguishers on Class D fires.
Fire extinguishers must be hung or placed where they are easily accessible but cannot be knocked over. Signs indicating the location of the fire extinguishers should be easily visible.
Fire extinguishers should be of an appropriate size for the incident. A UL rating system on the label indicates the coverage. For example, 4A:60B:C means that the extinguisher is adequate for 4 square feet of a Class A fire, 60 square feet of a Class B fire, or may be used on a Class C fire. It is important to know that the standard 10-15 pound fire extinguisher provides an uninterrupted stream of material for only about 30 seconds. All teachers and students should know how to use a fire extinguisher. A helpful mnemonic is the **PASS** rule:
Use of the Fire Extinguisher
1. **P**ull the ring or lock pin without squeezing the handle.
2. **A**im the nozzle at the base of the flame.
3. **S**queeze the handle.
4. **S**weep the fire retardant across the fire. Short blasts of the fire extinguisher should be directed at the base, not the center, of the fire.

Pull **A**im, **S**queeze **S**weep
When the fire goes out, stop squeezing and wait in case it flares up again. While you are fighting the fire, have someone get a second fire extinguisher in case the one you are using runs out.
After use, have the fire extinguisher recharged immediately.
3.2.5 Fire Blankets
Fire blankets are made of flame-retardant wool. Some old fire blankets were made from asbestos and should have been removed from school premises. 8 Fire blankets may be either folded or rolled vertically in wall-mounted cases and should be prominently labeled. Fire blankets are useful for smothering small fires. Clean fire blankets are useful in keeping accident victims warm to help prevent shock or to cover a wet victim after being under the emergency shower. The maximum suggested distance a person should travel to reach a fire blanket is 30 feet. 9 A folded fire blanket should be unfolded and

placed on the floor so the victim can wrap it around his/her body. When using a vertically mounted blanket, the victim should lie on the floor as soon as the blanket leaves the case. There is concern about using a fire blanket to wrap a person when his/her clothing or hair is on fire. The stop, drop, and roll procedure is probably the safest in most situations. A safety shower is very useful for extinguishing burning clothing. Fire blankets must be used cautiously because wrapping the body can force flames toward the face and neck, can hold heat next to the body, thus increasing severity of burns. Fire blankets are laden with fibers, dirt, and bacteria than can infect or further damage wounds from burns.

3.2.6 First-aid Kits

A medical treatment program is required as part of the chemical hygiene plan.

An adequately stocked first-aid kit is necessary to provide emergency aid until medical treatment is available. The first-aid kit should be stocked according to school policy following recommendations by the nurse or advising physician. For chemical exposure, the MSDS describes emergency medical treatment. Emergency phone numbers should be prominently posted. These numbers may include 911, local poison control center, and local hospital or ambulance. Staff should be trained in basic first aid and CPR according to school policy. Disposable latex gloves should be part of any first-aid kit to prevent the spread of blood-borne pathogens (section 6.5).

3.2.7 Refrigerators 6

Household refrigerators should never be used for chemical storage because the controls, switches, and defroster can spark and ignite flammable material. Food should **never** be stored in a chemical refrigerator. Chemical refrigerators should be clearly labeled "**No Food**". See section 7.5.5 for a more complete discussion of chemical refrigerators.

3.2.8 Master Gas and Electrical Cut-offs

In case of a fire or electrical accident, you should shut off the gas and/or electricity in the laboratory. Master electrical and gas cut-off switches should be available in each laboratory, clearly labeled, and should be readily accessible and easy to use. A master switch in a locked cabinet or one that requires a wrench to operate will not be useful in an emergency situation.

3.2.9 Ventilation: Fume Hoods and Exhaust Fans 6, 7, 10

Adequate ventilation is important in any room in which chemicals are used or stored. Inadequate ventilation limits the kinds of activities that can be done and the chemicals used in the laboratory. An adequate ventilation system should change the room air 4-12 times per hour. The Illinois Administrative Code specifies requirements for all educational rooms. The requirements under this code depends on the age of construction. Pre-1965 construction is covered under section 185, construction from 1965 until March 24, 1995 is covered under section 175, and construction after March 24, 1995 is covered under section 180. All air from laboratories should be exhausted outdoors and not recirculated in the building. The ducts should be situated so that exhausted air does not enter fresh air intakes.

Each classroom should have an emergency ventilation fan that can exhaust room air during an accidental spill or release of hazardous or irritating vapors. Lack of odor is not an adequate criteria of good ventilation since many chemicals such as mercury have no odor at hazardous levels. A knowledge of the hazardous chemicals being used helps reduce risk from exposure. If the presence of hazardous vapors is suspected, monitoring may be required. Emergency auxiliary ventilation should put a negative pressure on the room so air moves into the room and prevents vapors from being recirculated through the building. The occasional use of such auxiliary ventilation can reduce the conflict between the high energy costs of ventilation and the need to protect students and teachers from harmful levels of chemicals.

Chemical storerooms should have ventilation adequate to keep atmospheric levels of chemicals below their hazardous limits (threshold limit value (TLV) or permissible exposure limit (PEL)). As with room ventilation, 4-12 air changes per hour are recommended on a continuous basis to prevent buildup of toxic or hazardous concentrations of vapors. All ventilation systems should be regularly evaluated to ensure they are operating properly.

Fume hoods are intended to keep flammable gases, toxic vapors, or noxious odors from entering the general room atmosphere. The American Conference of Government Industrial Hygienists (ACGIH) recommends that hoods be used when working with chemicals having a TLV of 50 ppm or less. The concentrations of vapors in the room must be below the TLV listed in the MSDS for the chemical(s) used. Microscale procedures in which smaller quantities of chemicals are used can reduce exposure to hazardous and noxious vapors.

Rules for Using Fume Hoods

1. Do not store chemicals in a fume hood.
2. Fume hoods must be inspected for proper operation. Exhaust rates of 60-120 lfpm (linear feet per minute) have been recommended, but the ACS points out that exhaust velocity is not a reliable single criterion for hood performance. A smoke bomb may be used to visually monitor air flow. If you use a smoke bomb, you should notify others in the building and the fire department to prevent a false alarm. Inexpensive (less than $30) vaneometers are available to measure face velocity. The Illinois Administrative Code contains specific requirements for exhaust rate from laboratory fume. For specific requirements sections 185, 175, and 180 of the Illinois Administrative Code should be consulted depending upon the year of construction of the laboratory.
3. Keep the sash at its most efficient level.
4. Work as far inside the hood as possible, but keep your head outside the hood. A minimum working distance of 6 inches from the front of the hood is recommended.
5. Locate the hood away from windows, doors, and heavily trafficked areas because drafts can adversely affect the effectiveness of a hood.
6. The canopy-style hoods that are built over a lab bench are inadequate to ensure proper exhaust rates.

3.2.10 Evacuation Route

In case of an accident, evacuation may be necessary. When an emergency occurs, it is too late to develop a plan. Procedures for emergency evacuation from the laboratory must be carefully prepared and written into the chemical hygiene plan. The plans used for mandated fire and tornado drills can be adopted. You and your students should practice this plan so you can respond in case of an emergency. Establish a chain of communication so it is clear who notifies the office, who calls the fire department, and so on. Everyone in the laboratory should meet at a predetermined place to make sure everyone is out of the building. There should be two unobstructed paths of exits from the laboratory (for specific details consult Illinois Administrative Code 185, 175, or 180 depending upon the year of construction). In order to keep the aisles clear, students should not sit during the laboratory exercise. Stools should be pushed under the laboratory benches, and laboratory drawers should be kept closed.

3.2.11 Handicap Access

The manual "Teaching Chemistry to Students with Disabilities" is a valuable guide to ensure that students with disabilities receive the level of laboratory experience that is appropriate for the individual student (section 5.3.4). 11 In some cases, handicapped students are paired with another student or a laboratory assistant may help the student. Students with impaired mobility must have access to safety equipment, utility controls such as faucets and gas jets, restrooms, telephones, doors, and exits. Eye wash fountains and chains on safety showers must be accessible to students with impaired mobility.

Visually impaired students may need extra time to familiarize themselves with the location of sinks, eye wash stations, safety showers, exits, and other laboratory facilities and safety equipment. These students may need larger letters on labels, a magnifying glass, or Braille or large print instructions. Copies of the safety rules and safety contract should be made available in Braille or large print.

Students with impaired hearing may require visual warnings instead of the normal audible alarms. Hearing impaired students should be placed in a part of the laboratory where they have unrestricted view of the instructor.

3.3 Class Size

The National Science Teachers Association (NSTA) recommends that there be a maximum of 24 students in a laboratory class. These students must have immediate access to the teacher. 12 Large class size as a result of increased enrollment or budgetary constraints is an important issue for science teachers, since safety problems increase with larger class size. 13,14 The correlation of increased class size with increased accident rate has been documented. Not only does the chance of an accident increase as more students move about the room carrying equipment or chemicals, but direct supervision and instruction by the teacher becomes difficult in large classes. The presence of too many students in a lab can also create problems when they have to wait too long for chemicals and equipment or have too much down time. Under these circumstances, boredom sets in and increases the possibility of someone removing safety goggles, engaging in horseplay, or otherwise violating safety rules with the resulting risk of an accident. 15

A 1992 survey of state requirements revealed that only Florida has enforceable guidelines for class size in laboratories. Of the 43 states and Territory of Samoa that responded to the survey, twenty other states have guidelines which set class size at 25 or fewer or set limits based on the size of the room. Illinois and 16 other states have no class-size legislation.

If a teacher believes that the laboratory is too crowded for safety, he/she should place the concerns in writing to the department chair, principal, and superintendent. If the situation is not corrected, the teacher may request a liability waiver. If the situation is still not corrected, Steele, Conroy, and Kauffman recommend the teacher make a presentation of safety conditions and accident descriptions from local sources or the literature to the school board. The teacher and administration may enlist community support for a comprehensive laboratory safety program. Such a program would involve teachers, administrators, parents, industry, and the fire department in seeking a solution. Consider creative alternatives to increasing budgets: revise scheduling plans instead of adding staff.15

3.4 References

1. Flinn Scientific Inc. 1992. Cow Eye/Goggle Demo. *CHEM FAX* 10062

2. American National Standards Institute, I. 1990. *American National Standard for Emergency Eyewash and Shower Equipment*, Vol. ANSI Z358.1-1990. New York: American National Standards Institute, Inc.

3. Flinn Scientific Co. Inc. 1994. *Flinn Chemical Catalog & Reference Manual*, p. 567. Batavia, IL: Flinn Scientific Inc.

4. Committee on Chemical Safety. 1990. *Safety in Academic Chemistry Laboratories*, p. 47. Washington, D.C.: American Chemical Society. 5th ed.

5. Missouri Department of Elementary and Secondary Education. 1990. *Missouri Secondary Science Safety Manual*. Columbia, MO: Missouri Department of Elementary and Secondary Education

6. Committee on Chemical Safety. 1990. *Safety in Academic Chemistry Laboratories*. Washington, D.C.: American Chemical Society. 5th ed.

7. Committee on Hazardous Substances in the Laboratory. Assembly of Mathematical and Physical Sciences. National Research Council., ed. 1981. *Prudent Practices for Handling Hazardous Chemicals In Laboratories*. Washington, D.C.: National Academy Press

8. Illinois State Bar Association. 1992. Asbestos Abatement Act. In *Illinois Compiled Statutes*:105 ILCS 105.

9. Flinn Scientific Co. Inc. 1994. *Flinn Chemical Catalog & Reference Manual*, p. 532. Batavia, IL: Flinn Scientific Inc.

10. Flinn Scientific Co. Inc. 1987. Science Department Ventilation: Safety in the School Laboratory. *Flinn Fax* 87-1

11. Kucera, T. J., ed. 1993. *Teaching Chemistry to Students with Disabilities*. Washington, D.C.: American Chemical Society. 3rd ed.

12. National Science Teachers Association, ed. 1992. *NSTA Handbook 1992-1993*.

13. Holliday, W. G. 1992. Should We Reduce Class Size?: What the Research Really Says. *The Science Teacher* January: 14-17

14. Flinn, III, LC. 1994. Overcrowding in the Science Laboratory. In *Flinn Chemical Catalog and Reference Manual* :588-89. Batavia, IL: Flinn Scientific Inc.

15. Steele, M. M., Conroy, P. A., Kaufman, J. A. 1992. There's no Safety in Numbers: Class Size and High School Laboratory Safety - A Survey of State Legislation and Guidelines for Action at Local Levels.

Chapter 4

Classroom Strategies: Sample Introductory Safety Unit

Safety in the science laboratory requires common sense, preparation, and knowledge on the part of both the teacher and students. The use of unfamiliar equipment and chemicals in the science laboratory requires extra rules for behavior. Teaching students the proper way to handle materials in the school laboratory should also help them learn correct handling of chemicals found at home or on the job. Safety education must be an ongoing process and cannot be done only once during the year. Students cannot be expected to remember everything from the safety lecture given during the first week of class. Like any other activity, safety is learned only by continual reinforcement and practice. Clearly, students will not take safety rules seriously unless the teacher obeys and strictly enforces these rules. This chapter is an example of one way to instruct students on the importance of providing and maintaining a safe laboratory environment.

There are many other versions of safety rules, contracts, and tests. These samples are provided as only one of many possible versions that may be modified to meet local needs. The basic components of this Safety Unit should, however, be provided by all science teachers.

4.1 Guidelines for the Science Teacher

Section 4.1.1 presents some guidelines for classroom management. Guidelines for performing chemical demonstrations are found in section 4.1. Information on emergency signs is included in section 4.1.3. An emergency telephone list is provided in section 4.1.4. A sample accident report is presented in section 4.1.5.

Basic first aid procedures in case of an accident are summarized in section 4.1.6.

4.1.1 Guidelines for Classroom Management

1. **Have a set of safety rules**. Students must be informed of the rules of conduct and the proper handling of equipment and chemicals in a science laboratory (section 4.2.1; chapters 7 and 9).

2. **Use a safety contract.** A safety contract signed by the students and parents and kept on file by the teacher reinforces the importance of the rules and verifies that the teacher informed the students of the safety rules (section 4.2.2).

3. **Give a safety quiz**. A safety quiz may be given to assess understanding of safety rules and procedures and may be required before a student begins laboratory work (section 4.2.4)

4. **Reinforce safety instructions.** It is not enough to cover the rules in the first laboratory session. They must be reinforced with each laboratory period. A record of this training should be included in the teacher's lesson plan as legal proof of this additional safety instruction.1 For example, before doing an experiment using the Bunsen burner, the teacher might reemphasize the importance of fire safety and the requirement to wear safety goggles.

5. **Decorate with posters and sign**. Posters and signs are excellent ways of reminding students of safety rules and procedures. You can purchase commercial posters from scientific suppliers, but students can also design their own. This reinforces safety rules and gives them a connection with the overall safety plan. This could be a good activity when you have a substitute teacher or a shortened period.

6. **Teach proper handling of chemicals**. All chemicals pose some degree of hazard. It is the responsibility of the teacher to train students in the proper handling of chemicals

(section 7.5), to select chemicals that pose minimum risk (section 8.1.4), to reduce exposure to harmful chemicals as much as possible, to provide safe storage of chemicals (section 7.5), and to arrange for safe disposal of unwanted chemicals and chemical waste (section 8.2).

7. **Know the properties of the chemicals you are using.** Under the chemical hygiene plan, each school is required to keep a file of Material Safety Data Sheets (MSDSs) for every chemical in stock. The MSDS provides information about the physical properties, health and fire hazards, spill procedures, handling procedures, and first-aid treatment for a specified chemical. The MSDS and label instructions must be read and understood before using a chemical (section 7.2.1). Recently purchased chemicals usually have labels with a great deal of safety information, while older chemicals may have labels with very little information (section 7.5.6). Before using a chemical in the laboratory, students must be informed of its potential hazard, any special handling requirements, and disposal procedures.

8. **Consider microscale labs**. The easiest way to minimize exposure to a chemical and to reduce the volume of waste is to use the smallest amount possible (section 8.1.5). Microscale or semimicroscale laboratory experiments provide many of the same educational benefits as macroscale experiments and present many advantages. Microscale labs:

- are economical. Smaller quantities of chemicals are used and purchase price is reduced.
- are safer. Exposure to chemicals is based on the amount of the chemical distributed in the laboratory air. By reducing the amount of chemical used, the atmospheric level is reduced to safer and more pleasant levels.
- are less wasteful. The true cost of a chemical includes not only its purchase price but also the cost of disposal of the waste generated by its use.
- need less storage space. Microscale equipment and solutions can be stored in a small amount of shelf space. A shoe box can hold the solutions and equipment for an entire laboratory experiment

9. **Follow current practices**. The substitution of a less hazardous chemical in an experiment can also improve laboratory safety and minimize the need to dispose of hazardous waste (section 8.1.4). Be very cautious using older books and laboratory manuals as sources of experiments because laboratory practices have changed considerably in recent years. Do not use an experiment or demonstration that you have not tested prior to using it in the classroom.

10. **Control access to chemicals.** Access to chemicals must be strictly controlled by the teacher. Chemicals must be stored in a locked facility with limited access. Students should not have access to the chemical storeroom. Do not leave storage containers of chemicals in the classroom during an activity. Students should have access only to the chemicals and quantities needed. Do not leave chemicals accessible in the laboratory during free periods or when the room is being used by another class.

11. **Enforce safety rules**. Enforcement of safety rules is crucial. Students won't obey the rules if (1) they don't understand their purpose, (2) the rules are not followed by the teacher, (3) or the rules enforced haphazardly. Teachers need a policy for violations of safety rules and they need to follow it. The first violation may result in a warning, and the next violation may result in the student not being allowed to complete the experiment.

Some teachers have given warning slips like parking or speeding tickets for safety violations.1 The laboratory safety rules and the consequences for their violation should be posted in the laboratory.

12. **Set a good example.** Teachers need to follow the safety rules and wear required personal protective equipment, including eye protection. Special precautions are needed when doing chemical demonstrations in which the teacher is wearing eye protection and other personal protection, but the students are not. Also, to enhance their visibility, demonstrations are usually carried out on a much larger scale than laboratory experiments, thus increasing the hazard. Suggested guidelines for doing chemical demonstrations are given in section 4.1.2.

13. **Practice good housekeeping.** Both students and teachers have a responsibility to follow good housekeeping practices to prevent contamination of reagents and keep equipment and the laboratory clean (section 4.2.3).

14. **Be prepared in case of an accident**. In case of an accident, emergency procedures must be followed (section 3.2.10). The teacher should have a plan to follow and access to a telpehone and list of emergency telephone numbers (section 4.1.4).

4.1.2 Demonstration Guidelines

Chemical demonstrations are a very useful way of capturing student interest and presenting concrete examples of abstract concepts. However, demonstrations must be done in such a way that both the student and teacher are protected from possible harm. George Bodner has collected a number of examples of accidents that occurred during demonstrations that are very instructive.2 Safe demonstrations require that the teacher follow the same rules that apply to laboratory experiments. It is especially important that the teacher practice a demonstration before presenting it to a class. Use demonstrations from sources that provide information on the chemical principles involved, safety considerations, and waste disposal information. 3-6 The following guidelines developed by the American Chemical Society (ACS) for demonstrations at ACS-sponsored meetings should be followed by any demonstrator.

Minimum Safety Guidelines for Chemical Demonstrations

ACS Division of Chemical Education

Chemical Demonstrators Must:

1. know the properties of the chemicals and the chemical reactions involved in all demonstrations presented.
2. comply with all local rules and regulations.
3. wear appropriate eye protection for all chemical demonstrations.
4. warn the members of the audience to cover their ears whenever a loud noise is anticipated.
5. plan the demonstration so that harmful quantities of noxious gases (e.g. NO_2, SO_2, H_2S) do not enter the local air supply.
6. provide safety shield protection whenever there is the slightest possibility that a container, its fragments, or its contents could be propelled with sufficient force to cause personal injury.
7. arrange to have a fire extinguisher at hand whenever the slightest possibility for fire exits.
8. not taste or encourage spectators to taste any non-food substance.
9. not use demonstrations in which parts of the human body are placed in danger

(such as placing dry ice in the mouth or dipping hands into liquid nitrogen).
10. not use “open” containers of volatile, toxic substances (e.g. benzene, CCl_4, CS_2, formaldehyde) without adequate ventilation as provided by fume hoods.
11. provide written procedure, hazard, and disposal information for each demonstration whenever the audience is encouraged to repeat the demonstration.
12. arrange for appropriate waste containers for and subsequent disposal of materials harmful to the environment. Revised 6/4/88

4.1.3 Emergency Signs

Emergency signs are available from general lab supply companies and safety supply companies.

- Post lab safety rules in a prominent place in your laboratory.
- The outside doors to chemical storerooms should have NFPA 704 hazard diamonds for the benefit of fire department personnel.
- There should be signs that clearly state that chemical splash goggles are required.
- There should be signs that indicate procedures for evacuation in case of disaster.
- Location of fire extinguishers, eyewash fountains and safety showers should be clearly labeled.
- Cabinets used to store chemicals should be clearly labeled by type of hazard (e.g. acid, flammable).

4.1.4 Emergency Telephone List

A list of emergency telephone numbers should be posted in the laboratory and by telephones in the building, including the school office.

Fire
Ambulance
School Nurse
Medical
Emergency Response Unit
Office of Chemical Safety
Illinois Environmental Protection Agency
1-800-782-7860 (24 hour)
(217)-782-3637 (DIRECT)
Poison Control Center 1-800-543-2022
Police
Sanitation District

4.1.5 Sample Accident Report

Name of Student ______________________________________
Address ____ Home Phone
____
Age ________________
Date of occurrence _______________ Time of occurrence _____________________
Place of Occurrence (building, room, class name)____
Location (Check one) Activity (Check one)

lab bench demonstration
aisle regular experiment
classroom unauthorized experiment
hallway accidental contact
storeroom horseplay
other other
Cause (Check one) Body Parts Affected (Check one)
object in motion struck person face
person collided with object eyes
person fell hands, arms
clothing caught on object legs, feet
person wais caught between objects internal
chemical exposure body
overexertion
other
Describe result of accident:
Describe any damage to property:
Describe action taken:
EMS Trip Number (if transported to a medical facility) _____________
Names and addresses of witnesses

____

Name and address of supervisor at time of injury

____

Signature of person submitting report (name, date)

____

Signature of principal (name, date)

____

8

In case of an accident, the teacher may want to draw a diagram on the back of the accident report to show the location of the incident and the position of the teacher. Polaroid pictures can be used to show layout of the room. The EMS trip number can be obtained from the paramedic if transportation to a medical facility is required.

4.1.6 First Aid

Toxic substances in science labs can enter the body by inhalation of gas, vapor, or particulate matter (dust), by skin contact, by eye contact, by ingestion, or by injection. Injection of chemicals usually occurs from cuts by broken glass contaminated with hazardous chemicals. The first step is to try to identify the toxic substance and call for medical assistance. Keep calm at all times and prevent shock. Immediately notify the principal, the school nurse, and the parents.

- **inhaled poisons**- (symptoms: central nervous system problems like dizziness or headache)

1. Carry the victim to fresh air if possible. Open doors and windows to ventilate the room.
2. If the victim is not breathing, trained personnel should begin artificial respiration, but do not inhale the victim’s breath.

- **ingested poisons**

1. Maintain the student's breathing.
2. Collect a sample of the poison.

- **skin contact**

1. Wash away the chemical with large amount of water as quickly as possible. Continue to flush the area for 15 minutes.
2. Do not attempt to neutralize unless specifically approved by medical personnel.
3. Apply a sterile dressing.

Remember, toxic substances spilled on clothing often cause delayed and more severe problems than direct skin contact. Remove contaminated clothing before washing skin with water. Remove shoes if they will get wet from the drench so that chemicals do not wash into the shoes.

- **eye contact**

1. As quickly as possible, begin thoroughly washing the affected eyes, eyelids and face for 15 minutes. Assign someone to assist the person in washing his or her eyes.
2. If the student is wearing contact lenses, remove them if possible. If no eyewash fountain is available, use a rubber hose with a shower attachment or use cups of water.
4. If the injured person is lying down, gently hold the eyelids open and pour water from the inner corner of the eye outward. Do not allow the chemical to run into the other eye.
5. In the case of an alkaline burn or any other serious eye injury, immediately send for an ambulance so that first aid will not have to be discontinued during transport to medical facilities.
6. In the case of a minor injury, cover the eye with a dry, clean dressing. Caution the victim not to rub the eye.

- **heat burns**

1. Apply clean, cold, moist towels. Do not use ice or salt water. Continue as long as the pain persists
2. Apply a clean, dry dressing. Do not break blisters or remove dead skin. Do not apply ointments or creams.

- **electrical shock**

1. Disconnect the power source or pull the victim away using a dry wood stick or dry cloth. Make sure the rescuer has dry hands and is not standing in water. Do not use any metal or touch the victim directly
2. Maintain the victim's breathing.
3. Treat for shock symptoms (cover with blanket, elevate feet).

- **bleeding**

1. Put gloves on.
2. Apply firm pressure to the wound using a clean dressing.
3. Do not disturb the forming clot. Add additional layers of clean dressing.
4. Treat for shock.

Chapter 5
Legal Aspects of Teaching Science
5.1 Civil Liability for Injury

Teachers and administrators often worry about their liability — can they be sued? While it is impossible to state that districts and teachers will never be liable for injury caused in science laboratories, there is limited district and teacher immunity from claims for simple negligence. According to the Illinois School Code (105 ILCS 5/24-24):

Subject to the limitations of all policies established or adopted under Section 14-8.05, teachers, other certified educational employees, and any other person, whether or not a certified employee, providing a related service for or with respect to a student shall maintain discipline in the schools including school grounds which are owned or leased by the board and used for school purposes and activities. In all matters relating to the discipline in and conduct of the schools and the school children, they stand in the relation of parents and guardians to the pupils. This relationship shall extend to all activities connected with the school program including athletic and extracurricular programs and may be exercised at any time for the safety and supervision of the pupils in the absence of their parents or guardians.

Nothing in this Section affects the power of the board to establish rules with respect to discipline; except that each board shall establish a policy on discipline, and the policy so established shall provide, subject to the limitations of all policies established or adopted under Section 14-8.05, that a teacher, other certified employee, or any other person, whether or not a certified employee, providing a related service for or with respect to a student may use reasonable force as needed to maintain safety for the other students, school personnel or persons or for the purpose of self defense or the defense of property, shall provide that teacher may remove a student from the classroom for disruptive behavior, and shall include provisions which provide due process to students. The policy shall not include slapping, paddling, or prolonged maintenance of students in physically painful positions nor shall it include the intentional infliction of bodily harm.

This doctrine of *in loco parentis* (105 ILCS 5/24-24, 38-84a) has been upheld in court to afford certified staff the same type of immunity from civil liability for actions necessarily arising from the student-teacher relationship as a parent would enjoy for actions arising from the parent-child relationship (see Cates v. Cates, 156 Ill.2d 76, 1993). The Illinois Supreme Court has specifically noted the immunity of certified staff acting *in loco parentis* is limited to those duties necessitated by the need to maintain discipline and authority. The district, and its staff remain immune under certain circumstances under the local government and Governmental Employees Tort Immunity Act (745 ILCS 10/1-101). Willful or wanton misconduct is not subject to immunity.

Whether an injury arose from negligence or from actions necessary related to the student-teacher relationship will be determined from the facts in any given circumstance. It is impossible to speculate as to possible liability in any given situation. To minimize claims of liability, districts and teachers should follow the district policies on laboratory conduct and comply with the applicable laws and rules.

To defend against claims of negligence, Gass recommends the following steps for a teacher to take.1 These actions must be documented in case of future legal action since a lawsuit may be initiated years after the incident. This documentation could include a signed safety contract, results of a safety quiz, pre-lab tests with safety questions, and safety rules written into a laboratory notebook prior to performing the experiment. A reasonable and prudent teacher would:

1. provide prior warning of any hazards associated with an activity;
2. demonstrate the essential portions of the activity;
3. provide active supervision;
4. provide sufficient instruction to make the activity and associated risks understandable;
5. insure all necessary safety equipment is available and in good operating condition;
6. have sufficient training and equipment available to handle an emergency;
7. insure the place of the activity is as safe as reasonably possible.

5.2 Illinois State Law

5.2.1 Eye Protection

Students, teachers, and visitors are required by Illinois law to wear approved eye protection when participating in laboratory activities.2 Appropriate eye protection has the code "Z87" stamped somewhere on the eyewear and is suitable for the circumstances and hazards for which it is being used.

Every student, teacher, and visitor is required to wear an industrial quality eye protective device when participating in or observing any of the following courses in schools, colleges and universities:

a) vocational or industrial arts shops or laboratories involving experience with the following: hot molten metals; milling, sawing. turning, shaping, cutting, grinding, or stamping of any solid materials; heat treatment, tempering or kiln firing of any metal or other materials; gas or electric arc welding; repair or servicing of any vehicle; caustic or explosive materials;

b) chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids. Such devices may be furnished for all students and teachers and shall be furnished for all visitors to such classrooms and laboratories. The State Board of Education shall establish nationally accepted standards for such devices. (105 ILCS 115)

5.2.2 Health/Life Safety Code

Every 10 years or as required by the Illinois State Board of Education or regional superintendent, each school board shall survey its school buildings and execute any recommendations in accordance with the procedures set in the Health/Life Safety Code. An architect or engineer licensed in the state of Illinois is required to conduct the surveys and make a "safety survey report"

The school board approves the report and submits it to the regional superintendent. The regional superintendent may approve or deny the report and submit it to the state superintendent of education, who also may approve or deny it. If approved, the report gets a certificate of approval. Upon receiving the certificate of approval, the regional superintendent shall issue an order to effect any approved recommendations included in the report. Items should be prioritized. Urgent items shall be related to lifesafety problems that present an immediate hazard to the safety of students. Required items are those necessary to a safe environment but presenting a less immediate hazard to the safety of students. Urgent and required items shall reference a specific rule in the code that is currently being violated or will be violated in the next 12 months if the violation is not remedied. Urgent items should be corrected as soon as achievable. Required items shall be corrected in a timely manner, but no more than three years from the state superintendent's approval of the recommendation.

5.3 Federal Laws

In 1970 the U. S. Congress passed the Occupational Safety and Health Act. This act requires that certain precautions be observed to protect the safety and health of employees on the job. Teachers are considered employees under this act, but students are not covered. Under this act, OSHA (Occupational Safety and Health Administration) was established to regulate worker health and safety. NIOSH (National Institute for Occupational Safety and Health) was created as a service and information agency. In Illinois, public school teachers and all public sector employees are covered under the Illinois Health and Safety Act (1986) administered by the Illinois Department of Labor. Private school teachers are covered under federal OSHA.

The U.S. Environmental Protection Agency (EPA) has responsibility for the regulation of chemicals in the air, in water, and on land. The Illinois Environmental Protection Agency (IEPA) has regulatory authority in Illinois. The U.S. and Illinois departments of transportation have authority over the shipping of chemicals and their transportation over public roads. These agencies may regulate the moving of chemicals from one building to another or the transporting of chemicals for disposal.

The following table is a brief summary of some of the legislation that regulates the handling of chemicals. The citations are from the Code of Federal Regulations (CFR) and National Fire Association Protection Association (NFPA) codes.4

Act Activity Regulated Reference

Asbestos Asbestos materials 40 CFR 61
34 CFR 230, 763
Chemicals in Drinking Water Chemicals in drinking water 40 CFR 141, 144
Clean Water Act Control of discharges of hazardous substances
40 CFR 100, 401
Comprehensive Environmental
Response, Compensation, and
Liabilities Act (CERCLA)
Responsibility and compliance for
hazardous materials
40 CFR 302, 305, 306
Federal Insecticide, Fungicide and
Rodenticide Act (FIFRA)
Use of pesticides 40 CFR 150-199
Lead Contamination Control Act Lead in water supplies Public Law 100-572, October
1988
National Fire Protection Association
(NFPA)
Storage of flammable liquids NFPA Code 30
Protection of life and property in
laboratory settings.
NFPA Code 45
Life safety, technical standards for
fire prevention and safety.

NFPA Code 101
Occupational Safety and Health
Administration (OSHA)
Allowable standards in the
workplace.
29 CFR 1910
Occupational exposure to hazardous
materials in laboratories
29 CFR 1910.1450
Hazard communication standard 29 CFR 1910.1200
Occupational exposure to bloodborne
pathogens
29 CFR 1910.1300
Compressed gas standard 29 CFR 1910.101
Flammable liquids 29 CFR 1910.106
Eye/face protection 29 CFR 1910.133
Respiratory protection 29 CFR 1910.134
Quick drench 29 CFR 1910.151
Portable fire extinguishers 29 CFR 1910.157
Automatic sprinkler systems 29 CFR 1910.159
Record keeping requirements 29 CFR 1910.20
Protection of Stratospheric Ozone Release of freon to the Atmosphere 40 CFR 82
Radioactive Materials Hazardous radioactive materials 10 CFR 19, 20
Resource Conservation and
Reauthorization Act (RICRA)
Disposal of hazardous materials 40 CFR 241
Superfund Amendments and
Reauthorization Act (SARA)
Reporting, planning, and training
regarding hazardous materials
40 CFR 300
Toxic Substances Act (TOSCA) Chemical information, rules, PCBs 40 CFR 712, 716
Federal Hazardous Materials
Transportation Act
Transportation, labeling, handling,
training, classification, description,
marking, packaging, loading, and
storage of hazardous chemicals
49 CFR 107-180
6
7

5.3.1 Bloodborne Pathogens

Concerns about workplace exposures to bloodborne pathogens led the Occupational Safety and Health Administration (OSHA) to issue regulation 29 CFR 1910.1030 in 1991. This regulation was adopted by the Illinois Department of Labor in 1993 (Illinois Revised Statutes Ch. 48, Sec. 137.3 & 137.4).

The new standard requires employers to prepare an exposure control plan to bloodborne pathogens. The employer must perform an exposure determination to identify employees who may incur occupational exposure to blood or other potentially infectious materials. The exposure control plan must include a schedule and method of implementation for the various requirements of the standard. One requirement is the adoption of universal precautions to prevent exposure to bloodborne pathogens such as HIV (human immunodeficiency virus) and Hepatitis B (HBV). This statute applies to not only blood but to other body fluids contaminated with visible blood (section 6.5). Since all such specimens are to be considered infectious, adherence to these universal precautions and decontamination procedures are important for school nurses, coaches, janitors, and any teacher who might administer first aid or clean up a spill of body fluids, such as a nose bleed. Since cuts are the most common injury in science labs, teachers and school nurses need to be familiar with this policy.

5.3.2 Hazard Communication Standard (Right to Know)

In 1983 the Federal Hazard Communication Standard (29 CFR 1910.1200) became law. In 1984 Illinois adopted this standard as the "Toxic Substances Disclosure to Employees Act" (Public Act 83-248) — also known as the "Right to Know" law. Basically, this law requires employers whose employees use toxic substances to provide these employees with (1) material safety data sheets (MSDSs) that describe the properties, safe handling, and health hazards of toxic materials; (2) labeling of all toxic substances with product name and a hazard warning; and (3) annual training on the hazards of toxic substances, safe handling procedures, and how to read MSDSs.

5.3.3 Occupational Exposures to Hazardous Chemicals in Laboratories

In 1992 Illinois adopted the federal "Occupational Exposures to Hazardous Chemicals in Laboratories" legislation (29 CFR 1910.1450). This legislation requires all employers who are engaged in the laboratory use of hazardous chemicals to develop a chemical hygiene plan that details how each employee will be protected from overexposure to hazardous chemicals and describes specific work practices and procedures in the laboratory to minimize employee risk. Students are not considered employees under this law. However, this standard is based on the assumption that safety experts agree on a set of standards and practices for laboratory work that should be integrated into the chemical hygiene plan. This body of knowledge becomes the professional standards by which a teacher could be judged for negligence. Components of the chemical hygiene plan are:

1. designation of a chemical hygiene officer to oversee the implementation of the chemical hygiene plan;.
2. standard operating procedures for working with hazardous chemicals;
3. criteria that would trigger the implementation of exposure control measures including engineering controls, personal protective equipment, and hygiene practices;
4. procedures to ensure the proper functioning of fume hoods and other protective equipment;
5. employee information and training;
6. any circumstances in which a laboratory operation, procedure, or activity will require prior approval from the employer;
7. provision for medical consultation, surveillance, and examination;

8. provisions and procedures for designation of specific areas for handling particularly hazardous materials.

The chemical hygiene plan is a comprehensive plan for schools and covers all aspects of chemical safety in laboratories. A sample chemical hygiene plan is included in chapter 12 of this manual and may be modified for local needs. The chemical hygiene plan provides a way to get the entire school concerned with safety and could form part of the school safety plan. It is important to remember that the chemistry teacher is not the only person in the school who handles hazardous chemicals. Custodians who use cleaners, grounds people who use pesticides, teachers in art, print, and shop classes all use hazardous chemicals. Safety is everyone's business.

5.3.4 Americans with Disabilities Act

Congress passed the Rehabilitation Act of 1973 and the Individuals with Disabilities Education Act of 1975 to ensure that:

No otherwise qualified handicapped individual...shall, solely by reason of his handicap be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving federal financial assistance.

Both public and private schools are required to comply with provisions of the Americans with Disabilities Act of 1990. The Committee on Chemists with Disabilities of the American Chemical Society has published a manual *Teaching Chemistry to Students with Disabilities* that provides information for science teachers in regard to the classroom, laboratory, computer use, laboratory safety, and testing and evaluation. Handicapped students are entitled to a level of laboratory experience appropriate to the individual student. Illinois public facilities are required to meet the Environmental Barriers Act.6

5.4 How Can I Get Action?

When a safety problem is noticed, what steps should be taken? The science teacher is usually perceived to be the in-house expert and should use her/his best judgment to evaluate the situation and make a recommendation in writing to the safety committee, chemical hygiene officer, department head, and building principal.

Where can the teacher go to get input on his/her assessment of the situation? The school's written safety policy is a good place to start. If the school does not have a written safety policy, one should be developed as soon as the situation is resolved. The teacher may get input from teachers in other districts, local members of professional organizations such as the Illinois Association of Chemistry Teachers, Illinois Science Teachers Association, American Chemical Society, or the local fire department. The letter requesting correction of a safety concern should stress the importance of safety and ask for a written response within ten working days. If no action is taken, the letter might be sent to the school board as a second step. A third step could be to send the letter to the school's insurance carrier. The letters could be sent registered mail to provide a record of receipt.7 A sample "Request for the Correction of Safety Concern" is included. The following steps should be included in your written report:

1. a clear statement of the problem,
2. a list of possible solutions,
3. the recommended solution,
4. estimated cost.

The problem should be classified according to a priority system. One priority system could be (1) conditions that are immediately life threatening; (2) conditions that fail to meet current standards but are not immediately life threatening; and (3) other conditions that need to be corrected. Once the priorities are established, their remedies can be planned and budgeted.

5..4.1 Sample Request for Correction of Safety Concern11

Request for Correction of Safety Concern

____________ ________________________ ____________

(Date) (School) (Room)

The following is a safety concern in the science area:

Because this request is such an integral part of the safety policy of our department, written response is expected within 10 working days.

____

(Name)

____

(Signature)

cc. (Step 1) Department Chair, Safety Committee, Chemical Hygiene Officer, Building Principal

(Step 2) School Board

(Step 3) Insurance Carrier

5.5 References

1. Gass, J. R. 1990. Chemistry, Courtrooms, and Common Sense: Part I: Negligence and Duty. *J. Chem. Educ.* 67:51-55

2. Illinois State Bar Association. 1992. Eye protection in school act. In *Illinois Compiled Statutes*, ed. :105 ILCS 115.

3. Illinois State Bar Association. 1992. School Building Code. In *Illinois Compiled Statutes*, ed. :105 ILCS 5/2-3.12.

4. CHEMIS. 1994. *CHEMIS: Chemical Health and Environmental Management in Schools ¾ Administrative Manual*. Independence, MO: Pan-Educational Institute

5. Kucera, T. J., ed. 1993. *Teaching Chemistry to Students with Disabilities*. Washington, D.C.: American Chemical Society. 3rd ed.

6. Illinois State Bar Association. 1992. Environmental barriers act. In *Illinois Compiled Statutes*, ed. :410 ILCS 25.

7. Flinn Scientific Inc. 1994. *Flinn Scientific Safety Seminar: Practical Solutions to Laboratory Safety Problems*, video tape.

8. Gerlovich, J. A. et al. 1990. *The Total Science Safety System*. Waukee, IA: Jackel, Inc. 6th ed.

Chapter 6
Personal Safety Provisions

Providing a safe laboratory environment involves a combination of many efforts. In addition to proper training, procedures, ventilation, and emergency equipment, it is important to provide the laboratory worker with proper personal protection.

6.1 General Guidelines for Dress in a Laboratory

Prudent practice suggests that laboratory workers should not wear loose, skimpy, or torn clothing, unrestrained long hair, or hosiery. Loose or torn clothing can easily catch fire, be drawn across or dipped into chemicals, or become ensnared in apparatus and moving machinery. Clothing provides layers of protection to the skin and allows you to remove much of the contamination with the clothing. Skimpy clothing offers little protection to the skin in the event of chemical splash. Hosiery should not be worn since it will react with acids and some other chemicals, trapping the chemicals next to the skin. Trapped chemicals would increase the likelihood of severe chemical burn. If the possibility of chemical contamination exists, personal clothing that will be worn home should be covered by protective apparel.

Finger rings should be removed if working with equipment that has moving parts or with chemicals. Rings can react with chemicals or puncture laboratory gloves. Some chemicals can get trapped under rings and irritate the skin. Shoes should be worn at all times in buildings where chemicals are stored or used. Perforated or open-toed shoes, sandals, or cloth sneakers should not be worn in laboratories as they do not offer protection against spilled chemicals.

6.2 Protective Apparel

It is advisable that protective apparel be worn over street clothes in teaching laboratories when chemicals are in use. Laboratory coats and aprons each have a place in laboratories depending on the hazards involved. Laboratory coats are intended to prevent contact with dirt and the minor chemical splashes or spills encountered in laboratory work. The cloth laboratory coat is, however, primarily a protection for clothing and may itself present a hazard (e.g., combustibility) to the wearer. Cotton and synthetic materials that offer fire resistance are satisfactory, but rayon and polyesters are not. Laboratory coats do not significantly resist penetration by organic liquids and, if significantly contaminated by them, should be removed immediately.

Plastic or rubber aprons provide better protection from corrosion or irritating liquids but can complicate injuries in the event of a fire. Furthermore, a plastic apron can accumulate a considerable charge of static electricity and should be avoided in areas where flammable solvents or other materials could be ignited by a static discharge. Laboratory aprons have the advantage of being easily cleaned readily if contacted by chemicals, while lab coats may need to be laundered.

6.3 Contact Lenses in a Laboratory

The wearing of contact lenses in laboratories is a controversial issue, especially when some students who wear contacts do not own eyeglasses. Of 37 academic institutions (generally universities) responding to a SafetyNet inquiry, not one institution permitted free use of contact lenses, 16 forbade use, and 21 allowed contacts with certain restrictions.

Safety in Academic Chemistry Laboratories, an inexpensive, highly distributed booklet published by the American Chemical Society (ACS), provides a prudent and historically common response to the wearing of contacts:

Wearing of contact lenses in a laboratory is normally forbidden because contact lenses can hold foreign materials against the cornea. Furthermore, they may be difficult to remove in the case of a splash. Soft contact lenses present a particular hazard because they can absorb and retain chemical vapors. If the use of contact lenses is required for therapeutic reasons, fitted goggles must also be worn. An article in *Chemical Health and Safety*, also published by ACS, reported on a study by Rengstorff and Black, which generally found that contact lenses minimized injuries or protected the eyes from more serious injury in accidents involving metal particles, painting fumes, and chemical splashes from solvents and acids. In the same article, the author agreed that the difficulty of removing contacts in the case of splash is a major concern but suggested that, if contact lens wearers are identified and medical and first-aid personnel are properly trained, the risk can be minimized. In another article in the same issue of *Chemical Health and Safety*, the author addresses the problem of contacts and chemical fumes:

It is improbable that the corneal response to volatile substances would be affected significantly by the wearing of a rigid contact lens, because these substances would be eliminated rapidly by tear flow; however, water-soluble gases, fumes, and substances capable of binding to, or being absorbed into, hydrogel lens materials would be expected to produce prolonged exposure resulting in more severe or chronic response. Contact lens wearers who experience symptoms should not wear their lenses in such environments and ensure that their lenses are properly cleaned and rinsed before reuse. Severely soiled lenses must be replaced. If a chemical enters the eye, emergency treatment (flushing with water) must begin immediately (section 3.2.2). For washing to be effective for contact lens wearers, the lens must be removed quickly. Therefore, it is extremely important to be aware of those persons who wear contact lenses. If students are allowed to wear contacts, it is recommended that a list of all students who wear contacts be available in the lab.

Students should acknowledge their awareness of the problems with wearing contact lens in the safety contract.

6.4 Personal Protective Equipment

Appropriate personal protective equipment (PPE) must be worn by students, teachers, and visitors. Following is a discussion of the different types of PPE and their applications and use.

6.4.1 Eye Protection

Industrial quality eye protection is required by state law in all chemical or combined chemical-physical laboratories (section 5.2.1). Eye protection is available in various forms. The type of eye protection must be matched to the hazards present.

- **Chemical splash goggles** provide eye protection from chemical splash and physical impact. They are required where chemicals are being used and a hazard of liquid or dry particle chemicals exists. Unventilated splash goggles, if properly fitted, could reduce fume contact for soft contact wearers. "Visitor's glasses" or other safety glasses do not substitute for chemical splash goggles.
- **Face shields** provide protection (for a greater area of the face) from chemical splash and physical impact. Face shields should not be used in place of chemical splash goggles, but in addition to them since they provide little side, top, and bottom splash protection.

Face shields come in different lengths; only the longest face shields offer protection for the throat which is a vulnerable area.

- **Safety glasses and safety goggles** provide protection from physical impact, not from chemicals. They should be used only in areas such as shops where projectiles may be encountered.
- **Laser safety goggles** provide protection from the high intensity beam of lasers. These goggles are generally specific to certain ranges of wavelengths (section 10.4). Normal prescription eyeglasses do not afford appropriate protection. Most eye protection is now designed to fit over prescription glasses. Prescription safety glasses with side shields are available and are useful for many applications but do not provide proper protection from chemical splashes. It is worth the effort of shopping around to find eye protection that is effective, comfortable to wear, easily cleaned and durable, and meets the ANSI Z87 standard. It is strongly suggested that any already-existing laboratory eye protection that does not have the Z.87 marking be discarded.

6.4.2 Hand Protection

Personal protective equipment for the hands must also be correlated to the types of hazards present. Gloves are available for protection from the following hazards:

- sharp edges / cutting hazards
- abrasions
- chemicals
- cold (cryogenics)
- heat

Consider fit, flexibility, and grip when selecting all gloves. Also take into account the type of chemicals with which the hand will come into contact. Both material used and thickness of the gloves often affect how long the gloves will be effective. Gloves purchased from local grocery or outlet stores should have their labels checked to determine if they are suitable for the intended application. A chemical resistance selection chart for common types of chemical-resistant glove materials follows:

Resistance to Chemicals of Common Glove Materials[5]

(E = Excellent, G = Good, F = Fair, P = Poor)

Chemical	Natural Rubber	Neoprene	Nitrile	Vinyl
Acetaldehyde	G	G	E	G
Acetic acid	E	E	E	E
Acetone	G	G	G	F
Acrylonitrile	P	G	—	F
Ammonium hydroxide (sat)	G	E	E	E
Aniline	F	G	E	G
Benzaldehyde	F	F	E	G
Benzene (a)	P	F	G	F
Benzyl chloride (a)	F	P	G	P
Bromine	G	G	—	G
Butane	P	E	—	P
Butyraldehyde	P	G	—	G
Calcium hypochlorite	P	G	G	G
Carbon disulfide	P	P	G	F

Carbon tetrachloride (a) P F G F
Chlorine G G — G
Chloroacetone F E — P
Chloroform (a) P F G P
Chromic acid P F F E
Cyclohexane F E — P
Dibenzyl ether F G — P
Dibutyl phthalate F G — P
Diethanolamine F E — E
Diethyl ether F G E P
Dimethyl sulfoxide (b) — — — —
Ethylacetate F G G F
Ethylene dichloride (a) P F G P
Ethylene glycol G G E E
Ethylene trichloride (a) P P — P
Fluorine G G — G
Formaldehyde G E E E
Formic acid G E E E
Glycerol G G E E
Hexane P E — P
Hydrobromic acid (40%) G E — E
Hydrochloric acid (conc) G G G E
Hydrofluoric acid (30%) G G G E
Hydrogen peroxide G G G E
Iodine G G — G
Methylamine G G E E
Methyl cellosolve F E — P
Methyl chloride (a) P E — P
Methyl ethyl ketone F G G P
Methylene chloride (a) F F G F
Monoethanolamine F E — E
Morpholine F E — E
Napthalene (a) G G E G
Nitric acid (conc) P P P G
Perchloric acid F G F E
Phenol G E — E
Phosphoric acid G E — E
Potassium hydroxide (sat) G G G E
Propylene dichloride (a) P F — P
Sodium hydroxide G G G E
Sodium hypochlorite G P F G
Sulfuric acid (conc) G G F G
Toluene (a) P F G F
Trichloroethylene (a) P F G F
Tricresyl phosphate P F - F

Triethanolamine F E E E
Trinitrotoluene P E — P
(a) Aromatic and halogenated hydrocarbons will attack all types of natural and synthetic types of glove materials. Should swelling occur, the user should change to fresh gloves and allow the swollen gloves to dry and return to normal.
(b) No data on the resistance to dimethyl sulfoxide of natural rubber, neoprene, nitrile rubber, or vinyl materials are available; the manufacturer of the substance recommends the use of butyl rubber gloves.

6.4.3 Respiratory Protection

The use of respirators requires a special training program be put into place. The use of respirators by untrained personnel or students is not recommended. If respirators are not fitted and maintained properly, they may provide a false sense of security with no actual protection. If respirators are necessary, professional help should be obtained to help set up the necessary training program.

6.5 Precautions Against Bloodborne Pathogens

Each school should have a plan for management of infectious diseases, including bloodborne pathogens (section 5.3.1). Since cuts are common lab injuries, science teachers and students should be aware of legal requirements for handling and cleaning any materials exposed to blood and other sources of potentially infectious agents. **All blood should be considered infectious regardless of the source.** Avoid contact with any bodily fluids.

Bloodborne pathogens are microorganisms (e.g., viruses or bacteria) present in human blood and may cause disease in humans. Examples of bloodborne pathogens include the human immunodeficiency virus (HIV) which causes AIDS (acquired immunodeficiency syndrome) and hepatitis B virus (HBV) which causes hepatitis B infections. Other bloodborne pathogens include the microorganisms that cause syphilis and malaria.

Bloodborne pathogens can be transmitted if blood or certain body fluids (any human body fluid containing visible blood; semen; vaginal secretions; or fluids surrounding internal organs, the joints, or a fetus) from someone infected with a bloodborne pathogen gets into the mucous membranes (e.g., eyes, nose, mouth) or directly into the bloodstream through skin that is damaged (e.g., scraped, cut, abraded) or punctured (e.g., needlestick injury). HIV and HBV are also transmitted sexually and an infected woman can infect her unborn child before or during birth.

The problem experienced when handling these fluids is that you can't tell if something is infectious. Many people infected with bloodborne pathogens don't even know they have an infection. Their blood and some body fluids (any human body fluid containing visible blood; semen; vaginal secretions; or fluids surrounding internal organs, the joints, or a fetus) are still infectious even if they don't feel sick.

Universal precautions is a concept that is extremely important in reducing the risk of bloodborne pathogen infection. Practicing universal precautions means that you treat all human blood and some body fluids as if they are contaminated with bloodborne pathogens. Body fluids that do not require practice of universal precautions are sweat, sputum, saliva, urine, feces, vomit, or tears **unless** these body fluids are contaminated with visible blood.

It is preferable to avoid the need for personal protective equipment (PPE) through engineering controls and safe work practices. Examples of engineering controls in a chemistry laboratory include providing sinks for hand washing, "sharps" containers for broken glass and other sharp objects, and equipment and supplies such as pre-polished sections of glass tubing which minimize the chance of cuts. Examples of work practices include proper training on insertion of tubing in stoppers and other procedures that would minimize the chances of students or janitorial staff cutting themselves.

Personal protective equipment should be readily available so that, if there is for any reason a release of body fluids, the body fluid can be safely cleaned up or if there is need for first-aid, the responder can be protected from body fluids. This PPE may include gloves (e.g., disposable surgical gloves), mouthpieces, resuscitation bags, pocket masks, or other equipment that does not permit blood or other potentially infectious materials to reach or pass through to the responder's street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time the protective equipment will be used.

Any surfaces contaminated by body fluids should be cleaned up with an appropriate disinfectant (e.g., freshly made 1:10 household bleach/water dilution) while wearing protective gloves. Follow label directions for blood cleanup, especially the amount of time the disinfectant should be allowed to remain on the surface. Contaminated articles such as broken glassware should be picked up by mechanical means, such as by dustpan rather than by hand.

Unless materials used for cleanup are dripping blood or appear as if they would drip blood if squeezed, the waste materials may be disposed in the regular waste stream. As long as the blood is contained within the material used to clean it up, it cannot be released and transmit any infectious agents. If the material is dripping or looks as if it would drip if squeezed, place this material in a closed plastic bag and label it as biohazardous material. The biohazardous material must be treated (e.g., autoclaving or incineration) and disposed of as potentially infectious medical waste, which is regulated by the Illinois Environmental Protection Agency. It is preferable to avoid creating biohazardous waste by using excess amounts of absorbent material to collect blood so that all the blood is contained within the absorbent material and will not drip.

If you are administering first aid, gloves, mouthpieces, resuscitation bags, or pocket masks can help minimize contact with body fluids. Immediately or as soon as feasible after removing gloves, the responder should wash hands and any skin that came in contact with blood or other potentially infectious materials with soap and water. If you voluntarily choose to respond to an accident in a laboratory and to provide first aid, your response is called a "Good Samaritan" act. You should be aware of the risks of exposure to blood and some body fluids and should follow the precautions outlined above for your own protection, but your response is not mandated or regulated. However, if your job requires you to provide first aid and/or to handle blood and body fluids, your employer is required to train you and provide some additional protection, and you are required to follow certain procedures to protect yourself.

6.6 Medical Consultation

Medical consultation should be sought for any symptoms thought to arise from chemical overexposure, any event such as a major spill, leak, or explosion that may have resulted in an overexposure, or a bloodbone pathogen exposure incident. Employees are entitled to medical evaluation if there has been an accident, if routine monitoring shows levels of hazardous materials above the permissible exposure limits (PEL), or if there are signs and symptoms of exposure.

6.7 References

1. Committee on Hazardous Substances in the Laboratory. Assembly of Mathematical and Physical Sciences. National Research Council., ed. 1981. *Prudent Practices for Handling Hazardous Chemicals In Laboratories*, p. 161. Washington, D.C.: National Academy Press

2. Committee on Chemical Safety. 1990. *Safety in Academic Chemistry Laboratories*, p. 3. Washington, D.C.: American Chemical Society. 5th ed.

3. Segal, E. B. 1995. Contact Lenses and Chemicals: An Update. *Chemical Health and Safety* Jan/Feb:19

4. Cullen, A. P. 1995. Contact Lens Emergencies. *Chemical Health and Safety* Jan/Feb:23-24

5. Committee on Hazardous Substances in the Laboratory. Assembly of Mathematical and Physical Sciences. National Research Council., ed. 1981. *Prudent Practices for Handling Hazardous Chemicals In Laboratories*, pp. 159-60. Washington, D.C.: National Academy Press

Chapter 7
Safe Handling of Hazardous Materials
7.1 How Hazardous Substances Cause Injury

Hazardous substances can cause injury in several different ways. For example:

- injury by destruction of body tissue, as in an acid burning the skin;
- injury by poisoning, as in eating a poisonous plant;
- injury by displacing the air to be inhaled, such as being in an unventilated room while filling a Dewar with liquid nitrogen;
- injury by force, such as in an explosion.

The study of how substances cause harm is the study of toxicology. All materials can cause harm depending on their use or misuse. The simplest example of this is water, which is beneficial if taken by glass in reasonable quantities but causes many deaths through drowning each year. The book *Improving Safety in the Chemical Laboratory* discusses toxicology and other aspects of chemical safety in greater detail.

In case of exposure to hazardous substances, there are three factors to be considered:

1. **Dose** — the amount of exposure, as in a milliliter or a gallon. In general, the larger the dose, the less time it will take to produce an injury.
2. **Duration and frequency** — how long and how frequent is the exposure. In general, the longer the duration of the exposure, the more severe the injury will be. This is why it is important to wash off a chemical as soon as possible after contact. The frequency of the exposure can affect the type, time of onset, extent, and severity of the toxic effect. Some chemicals cause injury only after long-term exposure (they are chronically toxic) while others cause injury after a single exposure (they are acutely toxic).
3. **Route** — how the exposure takes place. This is through ingestion (by mouth), inhalation (breathing through the nose or mouth) or absorption through cuts, or contact with the eyes.7-2

There are many types of hazardous substances. These hazards are discussed in detail in section 7.4.

- carcinogen — chemical or physical agents that cause cancer;

- developmental and reproductive hazards — cause adverse effects on male or female reproductive systems or cause adverse effects on developing organisms;

- corrosive substances — cause visible destruction or alterations in living tissue;

- irritants - cause reversible inflammatory effects on living tissue at the site of contact by a chemical;

- hazardous substances with toxic effects of specific organs — may damage organs such as liver, nervous system, or blood;

- allergens — cause an allergic reaction after repeated exposure;

- flammable liquids — have the potential to readily catch fire and burn in air;

- explosive substances — may decompose under conditions of mechanical shock, elevated temperature, or chemical action, resulting in the release of large volumes of gases.

7.2 Obtaining Information on Specific Substances

There are four common sources of information on chemicals:

1. Material Safety Data Sheets (MSDSs). MSDSs contain information on physical data, health and fire hazards, spill procedures, handling procedures, and first aid for substances that are currently commercially available. Chemical suppliers are required by law to supply MSDSs for purchasers. Schools are required by law to retain and have available (readily accessible tothose working in laboratories) MSDSs that are received with orders.

2. Container labels also provide a great deal of safety information. It is typical for chemical suppliers to standardize their labels so that safety information is easily located on any label from the same supplier. Many suppliers also incorporate a storage scheme into their labels. The supplier's catalog will generally explain the labeling system used.
3. Books can provide more detailed information on chemicals than are available in MSDSs. A list of selected reference material is included in chapter 11.
4. Chemical catalogs from suppliers often containsafety information. There are often sections on safety and disposal, and specific hazards are listed with the chemical descriptions.
5. Internet offers a great deal of information. Currently, the University of Utah has many material safety data sheets available on its gopher (gopher://atlas.chem.utah.edu:70/11/MSDS). Additional services and information will undoubtedly become available.

7.2.1 Reading Material Safety Data Sheets

Every school laboratory should have access to Material Safety Data Sheet (MSDS) files. MSDSs were created with worker safety in mind. They give details about chemicals and their hazards. MSDSs are not required on laboratory chemicals if equivalent data exists; however, employers must retain MSDSs that are forwarded to them. Currently there is no standard format for MSDSs, however, they should supply the following information:

2

Identity

- Name of the chemical
- Name, address, and phone number of the supplier
- Chemical formula and EPA number

Physical Characteristics

- Boiling point — low boiling flammable liquids are special fire hazards
- Vapor pressure — high values mean easy inhalation
- Vapor density — high density means vapors accumulate in low areas
- Water solubility
- Appearance and odor
- Specific gravity
- Water reactivity — important for cleanup operations

7-4

Special hazards

- Flashpoint — lowest temperature at which vapor will ignite with a spark.
- Auto-ignition temperature — lowest temperature at which material will ignite spontaneously.
- Fire-fighting information — which extinguishing material to use (dry chemical, CO2, foam, etc.).
- Explosive limits — maximum concentrations of vapors allowed

Reactivity Data

- Stability and reaction paths of dangerous decomposition
- Health hazard data
- Routes of exposure - inhalation, absorption through skin, etc.
- Health symptoms — irritant, corrosive, carcinogen, etc.
- Emergency first aid

Personal Protective Equipment

- Respiration, goggles, gloves
- Types of ventilation required
- Hygiene procedure — washing hands after use, etc.

Hazardous Waste Disposal

- Protective equipment to use
- Spill cleanup
- Method of disposal

7.3 Eye Damage from Hazardous Substances

Despite education and provision of protective equipment, the accidental splashing of hazardous substances into the eye is one of the most frequent causes of serious eye injury in the workplace and other environments. Most common organic solvents react physically with the external ocular tissues and cause a loss of cells from the outer surface of the eye with accompanying severe discomfort. Detergents and surfactants may produce a similar response with far fewer symptoms. Concentrated acids and alkalis, when splashed into the eye, result in the rapid destruction of the eye and lids; if prompt emergency irrigation is not initiated, severe and permanent damage will result. Acids tend to be self-limiting, while alkalis may progressively disrupt, soften, and penetrate the eyeball with disastrous results.

7-5

7.4 Classes of Hazardous Substances

Many substances we encounter in the laboratory are known to be toxic, corrosive, or flammable or to pose other hazards. It is essential that any person working with chemicals understand the types of hazards they might come into contact with. This section will address the major classes of hazardous substances.

7.4.1 Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period. Chronic toxins are particularly insidious because they may have no immediate harmful effects.

Below is a list of chemicals associated with carcinogenic effects: It is always a good idea to consult an MSDS before doing any experiment. If the chemical you are working with is listed as being a known or suspected carcinogen, pay special attention to exposure limits and handling.

Known Human Carcinogens Probable Human Carcinogens Known Animal Carcinogens

Arsenic Powder Acrylonitrile Acetamide
Arsenic Pentoxide Cadmium Powder Aniline (or any of its salts)
Arsenic Trichloride Cadmium Chloride Beryllium Carbonate
Arsenic Trioxide Cadmium Sulfate 1,2-Dichloroethane (Ethylene Dichloride)
Asbestos Carbon Tetrachloride 1,4-Dioxane (p-Dioxane)
Benzene Chloroform Formaldehyde
Benzidine Ethylene Oxide Lead Diacetate
Chromium Powder Nickel Powder Nickel (II) Acetate
Chromium (IV) Oxide o-Toluidine Thioacetamide
Lead Arsenate Urethane (Ethyl Carbamate)
Sodium Arsenate
Sodium Arsenite
Vinyl Chloride

Asbestos is a mineral-based material that is resistant to heat and corrosive chemicals. Although asbestos is often bonded or woven for laboratory uses, it can eventually wear down (become friable), releasing fibers into the air. Asbestos exposure may cause lung cancer, pleural mesothelioma (a cancer of the lining of the lungs), peritoneal mesothelioma (a cancer of the lining of the abdominal cavity), and cancer of the digestive system. All types of asbestos can cause disease.

In 1972 the OSHA standard for maximum exposure in an 8-hour day was five (5) fibers (longer than 5 micrometers) per cubic centimeter of air. In November, 1983, an emergency temporary standard lowering the exposure to 0.5 fibers per cubic centimeter was issued by OSHA. Exposure to conditions that exceed this level can lead to asbestosinduced cancer and asbestosis.

Asbestos can be found in many older materials in the science laboratory. Typical examples are asbestos-centered wire gauze, heat-resistant gloves, heat-resistant plates/pads, fire blankets, filtering fibers, clamp padding, heating mantle insulation; as well as boards lining fume hoods, acid cabinets, drying ovens, and incubators. New equipment is asbestos-free but looks similar.

There are adequate substitutes on the market for all asbestos-containing materials. Asbestos should be removed by trained personnel. Asbestos is a hazardous air pollutant and must go to a designated landfill.

7.4.2 Developmental and Reproductive Toxins

Reproductive toxins cause adverse effects on the male or female reproductive systems. They are defined by the OSHA Lab Standard as including substances that cause chromosomal damage (mutagens) and substances with lethal or teratogenic (malformation) effects on fetuses. Many reproductive toxins are chronic toxins that cause damage after repeated or long duration exposures with effects that become evident only after long latency periods. Embryotoxins, substances that act during pregnancy, have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin.

Information on reproductive toxins can also be obtained from MSDSs. Pregnant women and women who might become pregnant should consult MSDSs before working with substances that are suspected to be reproductive toxins. The following table lists some common materials that are highly suspected to be reproductive toxins:

Reproductive Toxins
acrylic acid
aniline
benzene
cadmium
carbon disulfide
formaldehyde
formamide
iodoacetic acid
lead compounds
mercury compounds
nitrous oxide
phenol
toluene
vinyl chloride
xylene

This is only a partial list. It is the responsibility of teachers to evaluate each compound involved in their work and to determine whether it should be handled as a reproductive toxin.

7.4.3 Corrosive Substances

Any substance that causes visible destruction or alterations in living tissue by chemical action should be classified as corrosive. Major classes of corrosive substances include strong acids (e.g., sulfuric, nitric, hydrochloric, and hydrofluoric acids), strong bases (e.g., sodium hydroxide and potassium hydroxide), dehydrating agents (e.g., sulfuric acid, sodium hydroxide, phosphorus pentoxide, and calcium oxide), and oxidizing agents (e.g., hydrogen peroxide, chlorine, and bromine).

7.4.4 Irritants

Irritants are noncorrosive chemicals that cause reversible inflammatory effects on living tissue at the site of contact by a chemical. Many chemicals are classified as irritants, therefore skin contact with any laboratory chemical should be avoided.

7.4.5 Hazardous Substances with Toxic Effects on Specific Organs

Substances included in this category include hepatotoxins (substances that produce liver damage, such as nitrosamines and carbon tetrachloride); nephrotoxins (agents causing damage to the kidneys, such as certain halogenated hydrocarbons), neurotoxins (substances that produce their primary toxic effects on the nervous system, such as mercury, acrylamide, and carbon disulfide); agents that act on the hematopoietic system (such as carbon monoxide and cyanides that decrease hemoglobin function and deprive the body tissues of oxygen); and agents that damage lung tissue, such as asbestos and silica.

7.4.6 Allergens

An allergen is a substance that produces an allergic reaction after repeated exposure. Examples of allergens include chromium, nickel, formaldehyde, and isocyanates. Remember, there is considerable individual response to allergens, and some students may be more susceptible than others.

7.4.7 Flammable Liquids/Explosive Substances

Flammable substances have the potential to catch fire readily and burn in air. A flammable liquid itself does not catch fire; it is the vapors produced that burn. Two important properties of flammable liquids need to be considered while storing and handling them. The first is **flash point**, which is the lowest temperature, determined by standard tests, at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid within the vessel. The most hazardous liquids are those that have flash points at room temperature or lower. The second is the **ignition temperature** of a substance, which is the minimum temperature required to initiate self-sustained combustion independent of a heat source. Materials susceptible to spontaneous combustion include rags saturated with linseed oil, organic materials mixed with strong oxidizing agents (e.g., nitric acid, chlorates, permanganates, peroxides, and persulfates), alkali metals (e.g., sodium and potassium), finely divided pyrophoric metals, and phosphorus.

An explosive substance is any material that decomposes under conditions of mechanical shock, elevated temperature, or chemical action, and that releases heat and large volumes of gases. Organic peroxides are a special class of compounds that have stability problems that classify them among the most hazardous substances handled in laboratories. They are low-power explosives because of their extreme sensitivity to shock, sparks, or other forms of accidental ignition. The half-life of peroxides is dependent upon the circumstances, and their slow rate of decomposition may autoaccelerate and cause a violent explosion. Such factors as heat, friction, impact, light, and exposure to oxidizing and reducing agents may detonate peroxides. Any peroxide should be handled with extreme care. Aldehydes, ethers, compounds containing benzylic hydrogen atoms, alkenes, and vinyl compounds are known to form peroxides. When handling any peroxide, special handling precautions should be taken. Below are some suggestions:

- Limit the quantity being used to a minimum. Unused peroxides should not be returned to the container.
- Spills should be cleaned up immediately with a suitable absorbent.
- To reduce sensitivity to shock and heat, dilute with inert solvents. Avoid toluene; it is known to induce the decomposition of diacyl peroxides.
- Use ceramic or wooden spatulas instead of metal.
- Avoid all heat sources.

• Avoid friction, grinding, and all other forms of impact. Considerable danger is posed by solid peroxides that have crystallized from a solvent or have been left as a reside from evaporation. If this solid material is in a closed container, some peroxide may be present under the container cap and may detonate from the friction of opening the cap. Such containers should be disposed of by professionals.

• Pure peroxides should never be disposed of directly. Small quantities can be diluted with water to a concentration of 2% or less and then mixed with a reducing agent in a polyethylene bottle. The material can now be handled like any other waste chemical. Avoid mixing with any other chemicals during disposal. Many chemicals form peroxides upon exposure to light and oxygen. Some of these chemicals are diethyl ether (ether), dioxane, and tetrahydrofuran. Peroxide formers should be checked for peroxides every six months after opening or discarded six months after opening. Peroxide test strips are available from chemical suppliers. For more information on peroxides, consult *Prudent Practices for Disposal of Chemical from Laboratories*.

7.5 Handling Hazardous Substances Safely

7.5.1 Storage of Chemicals

Avoid the common practice of alphabetical storage of chemicals. Reactions of incompatible chemicals make spectacular demonstrations but can be a disaster in your storeroom. For example, **a**luminum foil and **b**romine react at room temperature producing enough energy to become incandescent. In addition, many incompatible concentrated acids (such as acetic acid and nitric acid) are often stored together. All chemicals in the stockroom and laboratory should be stored so as to avoid incompatibilities. (Refer to section 7.5.2 for a list of chemicals that are incompatible) Below is one example of how your chemicals could be separated in storage: 10

Class 1 — Flammable or combustible and not highly toxic and compatible with water
Class 2 — Flammable or combustible and not highly toxic and incompatible with water
Class 3 — Oxidizers and non-flammables, compatible with water
Class 4 — Oxidizers and non-flammables, incompatible with water
Class 5 — Air sensitive
Class 6 — Chemicals requiring refrigeration
Class 7 — Compressed gas cylinders, separated as to oxidizers, reducers, corrosives, toxics
Class 8 — Unstable chemicals (explosives)

Guidelines for Chemical Storage

• Use appropriate shelving or cabinets. If you use shelving with metal brackets, inspect the clips and brackets annually for corrosion and replace as needed.

• Store flammable liquids in approved fire cabinets.

• Make sure shelves holding containers are secure. Attach anti-roll lips on shelves to prevent containers from falling off.

- When opening newly received chemicals, immediately read the warning label to be aware of any special storage precautions such as refrigeration or inert atmosphere storage.

- Do not store chemicals in aisles or stairwells, on desks or laboratory benches, on floors or in hallways.

- Maintain a complete inventory in the room where chemicals are stored, and give a copy to your local fire department.

- Mark the acquisition dates on all peroxide-forming chemicals, and test them for peroxides or dispose of them after six months.

- Have spill cleanup supplies (absorbents, neutralizers) in any room used for chemical storage or use.

- Protect the school environment by restricting emissions from stored chemicals. Vents should be ducted to the outside.

- Use refrigerators of explosion-proof or explosion-safe design only! Standard refrigerators that have not been converted should never be used to store flammable chemicals. Label refrigerators **"NO FOOD".**

- Containers should be dated upon receipt, dated to be disposed where appropriate, and dated when opened (e.g., peroxides, anhydrous ethers, sodium nitrites).

- Chemical containers should be periodically checked for rust, corrosion, and leakage.

- Container labels should state name of the chemical, be firmly attached to the container, list hazards, and name of manufacturer or other responsible party.

- Chemical labels should be readable and free from chemical encrustation.

- Maintain a clear access to and from the storage areas.

- Where possible, storage areas should be planned with two separate exits.

Many of the catalogs of chemical suppliers give examples of various chemical storage schemes. Each school should decide which method will work best for it and implement the storage scheme.

7.5.1.1 Storage of Flammable and Combustible Liquids

OSHA specifies the storage facilities and limits the amount of flammable and combustible liquids that may be stored at a site. Only approved containers, cabinets, and areas described below shall be used store flammable and combustible liquids. No more than 10 gallons of these liquids may be stored outside a storage cabinet or storage room except in storage cans. All cabinets used for storage of flammable and combustible liquids shall be labeled "**FLAMMABLE ¾ KEEP FIRE AWAY**". The amount of flammable and combustible material stored should be limited to that required for one year of laboratory work. Do not store liquids so that they block aisles or doorways or are exposed to the sun's rays or sources of heat.

Classes of Flammable and Combustible Liquids

Class Flash Point Boiling Point Example

IA below 73oF (22.8oC) below 100oF (37.8oC) diethyl ether

IB below 73oF (22.8oC) at or above 1000F (37.8oC) ethyl alcohol

IC at or above 73oF (22.8oC) below 100oF (37.8oC) xylene

II at or above 100oF (37.8oC) below 140oF (60.0oC) acetic acid (glacial)

IIIA at or above 140oF (60.0oC) below 200oF (93.4oC) kerosene

IIIB at or above 200oF (93.4oC) -------------------------- olive oil

The maximum allowable container size for flammable or combustible liquids should conform to the following table unless the required purity would be affected by storage in metal containers or cause excessive corrosion of the metal container. In this case, liquids may be stored in glass containers of no more than one-gallon capacity.

Maximum Allowable Size of Containers

Container Size Class IA Class IB Class IC Class II Class III

Glass or approved container 1 pt 1 qt 1 gal 1 gal 1 gal

Metal (other than DOT drum) 1 gal 5 gal 5 gal 5 gal 5 gal

Safety cans 2 gal 5 gal 5 gal 5 gal 5 gal

Metal Drum (DOT spec.) 60 gal 60 gal 60 gal 60 gal 60 gal

- Metal cabinets used for storage of flammable or combustible liquids shall be double walled and have tightly sealed joints when the cabinet is closed.
- Wooden cabinets used for storage of flammable or combustible liquids shall be of plywood, 1-inch thick with rabbetted construction. When two doors are used, there shall be a rabbetted one-inch overlap between them.
- Approved containers or safety cans shall be of no more than 5 gallons in capacity having a springclosing lid and spout cover, and be designed to safely relieve internal pressure when subject to fire exposure. All containers should be closed when not in use. No more than 25 gallons of class I or Class II liquids combined shall be stored in safety cans outside a storage room or cabinet.
- All transfer of flammable liquids in a laboratory or room shall be performed in an operating fume hood that is free of open flames or other sources of ignition. Bulk transfer of flammable liquids shall be done in an approved solvent pouring room conforming to NFPA Codes 30-4310 and 30- 4320. All dispensing drums shall be grounded to protect against possible ignition from static electricity.
- No container for Class I or Class II liquids shall exceed a capacity of one gallon except in safety cans.
- No more than 10 gallons of Class I and Class II liquids combined shall be stored outside of a storage cabinet or storage room, except in safety cans.
- No more than 25 gallons of Class I and Class II liquids combined shall be stored in safety cans outside of a storage room or storage cabinet.

- No more than 120 gallons of Class I, Class II, and Class IIIA liquids shall be stored in a storage cabinet. Of this total, not more than 60 gallons may be of Class I and Class II liquids.
- No more than three storage cabinets may be located in a single fire area unless cabinets are separated by at least 100 feet.
- No more than 60 gallons of combustible liquids shall be stored outside of a storage room or storage cabinet.
- Quantities of flammable and combustible liquids in excess of those set forth above shall be stored in a storage room.
- Every inside storage room shall be provided with either a gravity or mechanical exhaust system.
- Suitable fire control devices, such as portable fire extinguishers or sprinkler systems, shall be available at locations where flammable or combustible liquids are stored.
- These safety standards do not apply to outside above-ground or below-ground storage containers.

7.5.2 Dangerous Combinations of Common Substances

When transporting, storing, using, or disposing of any substance, utmost care must be exercised to ensure that the substance cannot accidentally come into contact with an incompatible substance. Such contact could result in a serious explosion or the formation of substances that are highly toxic or flammable or both. Specific incompatibilities are listed on each MSDS. The following table is a guide to avoiding accidents involving incompatible substances:11

Incompatible Chemicals

Chemical Is Incompatible With

ALKALINE AND ALKALINE EARTH METALS (Sodium, Potassium, Cesium Lithium, Magnesium, Calcium, Aluminum) Carbon dioxide, water, carbon, tetrachloride, and other, chlorinated hydrocarbons. (Also, prohibit water, foam, and dry chemical on fires involving these metals.)

ACETIC ACID Chromic acid, nitric acid, hydroxyl containing compounds, ethylene glycol, perchloric acid, peroxides, and permanganates

ACETONE Concentrated nitric and sulfuric acid mixtures.

ACETYLENE Chlorine, bromine, copper, iodine, silver, fluorine, mercury, and their compounds.

AMMONIA (anhyd.) Mercury, chlorine, calcium hypochlorite, iodine, bromine, and hydrogen fluoride.

AMMONIUM NITRATE Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely-divided organics or combustibles.

ANILINE Nitric acid, hydrogen peroxide, and other strong oxidizing agents

BROMINE Ammonium, acetylene, butadiene, butane and other petroleum gases, carbide, turpentine, benzene, and finely divided metals.

CALCIUM CARBIDE Water (see also acetylene).

CALCIUM HYDROCHLORITE Acids, combustible or organic material, and ammonia.

CALCIUM OXIDE Water

CARBON, activated Calcium hypochlorite.

COPPER Acetylene, hydrogen peroxide.

CHLORATES Ammonium salts, acids, metal powders, sulfur, finely-divided organics

or combustibles.
CHROMIC ACID Acetic acid, naphthalene, camphor, glycerine, turpentine, alcohol, and other flammable liquids.
CHLORINE Ammonia, acetylene, butadiene butane, and other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, and finely-divided metals.
CHLORINE DIOXIDE Ammonia, methane, phosphine, and hydrogen sulfide.
FLUORINE Isolate from everything
HYDROCYANIC ACID Nitric acid, alkalies
HYDROGEN PEROXIDE Alcohols, glycerol, copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials aniline, nitromethane, caustic soda, and other strong alkalies.
HYDROFLUORIC ACID,(anhyd. Hydrogen Fluoride) Ammonia, aqueous or anhydrous
HYDROGEN SULFIDE Fuming nitric acid, oxidizing or corrosive liquids or gases.
HYDROCARBONS (Benzene, Butane, Propane, Gasoline,
Turpentine) Fluorine, chlorine, bromine, chromic acid, sodium peroxide.
HYDROXIDES (Sodium and Potassium) Inorganic acids, metals, explosives, organic peroxide ignitable substances.
IODINE Acetylene, ammonia (anhydrous or aqueous), hydrogen
MERCURY Acetylene, fulminic acid, ammonia.
NITRIC ACID (conc.) Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable gases, metallic powders, carbides, turpentine, organic acids, and flammable liquids.
NITROPARAFFINS Inorganic bases.
OXYGEN Oils, grease, hydrogen, flammable liquids, solids or gases.
OXALIC ACID Silver, mercury.
PERCHLORIC ACID Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils.
PEROXIDES, organic (organic or mineral); avoid friction.
PHOSPHORUS (white) Air, oxygen
POTASSIUM CHLORATE Acids (see also chlorate), organic substances.
POTASSIUM PERCHLORATES Acids (see also perchloric acid).
POTASSIUM PERMANGANATE Glycerine, ethylene glycolbenzaldehyde, sulfuric acid.
SILVER Acetylene, oxalic acid, tartaric acid, ammonium compounds.
SODIUM See alkaline metals (above).
SODIUM NITRATE Ammonium nitrate and other ammonium salts.
SODIUM OXIDE Water.
SODIUM PEROXIDE Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl and furfural.
SULFURIC ACID Carbides, chlorates, combustibles, perchlorates, water, permanganates, powdered fulminates, nitrates, picrates.
ZIRCONIUM Prohibit water, carbon tetrachloride foam, oxidizing materials, and dry chemical on zirconium fires.

7.5.3 Safety Cans for Storage and Transfer 12

Approved safety cans for flammable liquids are common in many schools, but

they are probably among the least understood safety equipment. The basic purpose of a safety can is to safely control the flammable vapors, while providing a convenient means of carrying, dispensing, and storing up to five gallons of flammable liquid.
This requires that the can:

- be leak-tight;

- automatically vent vapor at approximately 5 psi internal pressure to prevent an explosion in event of fire;

- Prevent flame from reaching the flammable liquid contents through the spout by means of a "flame arrester;"
- Automatically close after filling or pouring.

In addition to these basic safety requirements, safety cans must be damage - and wear resistant in normal usage and permit ready, convenient use in pouring, filling, and carrying. The cans should be properly marked to identify their contents. Safety cans should not be used for storage of waste solvents or corrosives as the flame arrestors can become plugged and the cans can rust through and leak. Polyethylene jerricans should be used for this purpose.

7.5.3.1 Bonding and Grounding

The flow of liquids from one container to another can cause a static charge to build up on one of the containers. If the electric potential becomes large enough, a spark will be produced between the containers and may cause the flammable liquid to be ignited. The buildup of static electricity is particularly hazardous when metal containers are used; however, several cases of a static discharge and subsequent ignition/explosion are known to have occurred involving plastic containers. To prevent such a build up, a procedure called bonding and grounding is utilized. When transferring flammable liquids between containers in amounts greater than a few ounces of milliliters, it should become common practice to use bonding and grounding.

Bonding refers to providing an electrical connection between the containers involved in the transfer of flammable liquid to prevent a difference in electrical charge from developing on the containers. The connection is commonly provided by a length of electrical wire fitted with an alligator clip at each end. One end of the wire is fastened to the container from which the liquid is flowing and the other end to the container receiving the fluid. Another way to prevent the build up of static electricity is to maintain direct contact between the two containers while the liquid is being poured.

Grounding provides a method of eliminating static electricity from the containers through a connection that allows a flow of the static charge to the "ground". Grounding is normally provided by connecting one of the containers (usually the stationary container) to a grounding source such as a metallic water pipe system or other electrical ground. Bonding and grounding are particularly important in areas where flammable liquids are stored and dispensed from 55 gallon containers.

7.5.4 Gas Cylinders

Compressed gases pose a unique hazard because they have the potential for simultaneous exposure to both mechanical and chemical hazards. Avoid the inhalation of gases such as helium or sulfur hexafluoride for demonstration purposes because of the danger of suffocation. It is preferable not to purchase flammable gases such as hydrogen (H2) or methane (CH_4) in large cylinders since they contain a large volume of gas that can be quite dangerous in the event of a fire. Cylinders of toxic gases, such as sulfur dioxide (S02), chlorine (C12), and nitrous oxide (NO), should not be considered for secondary school use. Small quantities of these gases can be generated as needed for experimental procedures.

Gas cylinders come in several sizes. Large-and medium- size cylinders can be refilled and are generally rented rather than being sold outright. Lecture bottles are small cylinders that are not refillable. Lecture bottles should be purchased from a supplier that will take the container back when it is empty, since disposal of lecture bottles can be very expensive. A refillable cylinder should not be totally emptied; this will allow the cylinder to be refilled without contamination.

Identification

- Contents should be clearly identified. Stenciled or stamped identification should be easily read.
- Color coding should not be used as a means of identification because cylinder colors vary from supplier to supplier. Labels on caps have no value because caps are interchangeable.
- All gas lines should be clearly labeled and coded to distinguish hazards (e.g., flammable, toxic, or corrosive).
- Signs should be posted in areas where flammable compressed gases are stored.

Storage

- Compressed gas cylinders should be used and stored in an upright position. They should be firmly secured at all times. Gas cylinders should be stored in a cool-dry place away from corrosive chemicals or fumes.
- Gas cylinders should be stored away from highly flammable substances and sources of heat.
- Empty gas cylinders should be labeled **EMPTY** or **MT**.
- Empty gas cylinders should be stored separately from full gas cylinders.
- Cylinders of toxic, flammable, or reactive gases should be used only in fume hoods.
- When storing or moving cylinders, the valve cap should be securely in place to protect the valve stem and valve.
- The valve cap should not be used as a lifting lug.
- Flammable or toxic gases should be stored at or above ground level, never in basements.
- If large gas cylinders are used, a cylinder cart should be available for transporting them to and from the storage area. Cylinders should not be dragged or rolled. A broken valve makes a compressed gas cylinder a potential rocket.

General Guidelines for Use of Compressed Gas Cylinders

Some general guidelines include:

1. All cylinders of flammable gases should be grounded before opening and when in use and should be kept away from sources of ignition.
2. Cylinder caps should not be pried open by inserting a lever into one of the holes in the cap because the valve could be accidentally opened.
3. Because of static buildup when discharged, cylinders of combustible gases, such as nitrogen and carbon dioxide, should be grounded if used in an explosive atmosphere.

4. Gas cylinders require a regulator or reducing valve to lower the pressure in the cylinder (commonly as high as 2500 psi) to operating pressure. Make certain that the characteristics for each valve are suitable (e.g., appropriate pressure ranges and fittings). Valves are threaded and fitted to prevent errors in connections, so never try to force or adapt one that does not fit.
5. Special cleaning measures are needed for compressed oxygen systems because any hydrocarbon that comes in contact with compressed oxygen will ignite spontaneously and, if contained, could cause an explosion.
6. When opening a cylinder valve, do so slowly, always standing away from the face of the outlet. Never hammer or wrench the valve handle in an attempt to open or close it if it is stuck.
7. Purchase gas cylinders only from sources that will accept the return of a cylinder due to faulty or frozen valves.
8. Only tubing and piping suitable for the pressures involved should be used for any gas under pressure.
9. Pressure-relief devices are required on all gas systems to prevent accidental rupture of system components.

7.5.5 Refrigerators

Cold storage is often recommended for flammable materials such as organic solvents and for biological specimens. Material stored in refrigerators should be sealed, double packaged if possible, and labeled with the name of the material, the date placed in the refrigerator, and the name of the person who stored the material. Uncapped containers should never be placed in a refrigerator. Containers should be capped so you can achieve a seal that is both vapor tight and unlikely to spill if the container is tipped over. Caps constructed from aluminum foil, corks, or glass stoppers often do not meet all of these criteria; capping containers by these means is discouraged. A current inventory should be maintained so that old chemicals can be disposed of after a specified storage period. All chemicals should be properly labeled. Labels should be waterproofed if stored for a long time. Transparent tape or commercial clear plastic sprays can be used to make the labels permanent. Do not use water-soluble markers for labels, because the moisture will soon cause them to become illegible.

Household refrigerators should not be used for chemical storage. The different control switches and defroster heaters and fans can spark, igniting flammable materials and causing fires and/or explosions. If the only refrigerator available is a household model, the following modifications are recommended: remove interior lighting activated by the door mounted switch, move the thermostat and any other contacts for electrical connections to a position outside the refrigerated compartment. Frost-free refrigerators are not recommended for laboratory use because of the many problems associated with attempts to modify them.

Laboratory refrigerators should be placed against fire-resistant walls, have heavyduty cords, and should be protected by their own circuit breaker. Food should never be stored in a refrigerator used for chemical storage. These refrigerators should be clearly labeled "**No Food**." Conversely, food refrigerators, which always must be outside of and away from the chemical work area, should be labeled "**Food Only ¾ No Chemicals**".

7.5.6 Labeling

Labeling should be used as a tool in the management of chemicals. Labels provide an immediate warning of potential hazards to persons handling a substance and they prevent the inadvertent creation of unknown substances that must be disposed of. The minimum information a label should contain should be the following:

- Name of the chemical as it appears on the MSDS.
- Appropriate hazard warnings.
- Name and address of the manufacture or other responsible party.

Any prepared solutions should be labeled with the information listed above, plus the concentration, date mixed, and the name of the person who prepared it. Several labeling systems are currently used in the workplace and in institutions. It is up to the school to adopt and implement a system that will work best for it. Once a system has been adopted, it is imperative that students be taught to understand and utilize it for their safety. Some examples of labeling systems are:

- National Fire Protection Association, NFPA 704 system.

The NFPA diamond is a familiar sight on buildings and rooms that contain hazardous materials. The diamond shows four hazard categories: flammability, reactivity, health, and other special categories. Each category has a rating of 0-4 with 0 indicating no hazard and 4 indicating extreme hazard. The white diamond is used for special hazards, such as water reactivity or oxidizers.

RED
YELLOW BLUE
WHITE
Flammability rating
Reactivity rating
Health Hazard rating
Other Hazard

- DOT Hazardous Materials Warning Labels

These labels are required on shipments of hazardous materials. They consist of a color-coded diamond with a symbol, written classification of the hazard, and a hazardous materials class number. Three examples of these signs are shown below.

- Precautionary Language Labeling, ANSI Z129.1.

The ANSI Z129.1 code requires the following minimum components on the label of a chemical container:

1. identification of contents of container
2. signal word and summary description of any hazard(s)
3. precautionary information — how to minimize hazard or prevent an accident
4. first aid in case of exposure
5. spill and cleanup procedures
6. any special instructions for physicians

For more information on each of these systems, contact your local fire department.

7.6 References:

1. Young, J. A. 1987. *Improving Safety in the Chemical Laboratory*. New York: John Wiley & Sons

2. Committee on Chemical Safety. 1990. *Safety in Academic Chemistry Laboratories*, pp. 22-26. Washington, D.C.: American Chemical Society. 5th ed.

3. Cullen, A. P. 1995. Contact Lens Emergencies. *Chemical Health and Safety* :23-24
4. Massachusetts Institute of Technology (MIT), Department of Chemistry. 1991. *Chemical Hygiene Plan*, p. 19. Cambridge
5. Maryland State Department of Education. *Maryland School Science Safety Project: Safety Manual K-12*, p. 105. : Maryland State Department of Education
6. Massachusetts Institute of Technology (MIT), Department of Chemistry. 1991. *Chemical Hygiene Plan*, p. 22. Cambridge
7. Massachusetts Institute of Technology (MIT), Department of Chemistry. 1991. *Chemical Hygiene Plan*, p. 23. Cambridge
8. Massachusetts Institute of Technology (MIT), Department of Chemistry. 1991. *Chemical Hygiene Plan*, p. 24. Cambridge
9. National Research Council. 1983. *Prudent Practices for Disposal of Chemicals from Laboratories*. Washington, D.C.: National Academy Press
10. University of Utah, Department of Chemistry. *Chemical Hygiene Plan*.

11. Committee on Chemical Safety. 1990. *Safety in Academic Chemistry Laboratories*, pp. 66-67. Washington, D.C.: American Chemical Society. 5th ed.
12. Maryland State Department of Education. *Maryland School Science Safety Project: Safety Manual K-12*, p. 86. : Maryland State Department of Education

Chapter 8
Waste Minimization Strategies and Chemical Waste Disposal

All laboratory work with chemicals eventually produces chemical waste. It is everyone's legal and moral responsibility to minimize the amount of waste produced and to dispose of chemical waste in a fashion that has the least impact on the environment. Depending on what is contained in the waste, some waste must be professionally incinerated or deposited in designated landfills, while other waste can be neutralized or discharged in normal waste streams.

In 1980 the U.S. Environmental Protection Agency (US EPA) put into effect federal regulations for a hazardous waste management system. These regulations were developed to establish a "cradle to grave" system for the management of hazardous wastes from all sources. In Illinois these regulations are administered by the Illinois Environmental Protection Agency.

The intent of this chapter is to provide schools with information which will help them to minimize the amount of chemical waste that is generated and effectively deal with chemical wastes that are produced.

8.1 Waste Minimization

Waste minimization is any action that reduces the amount and/or toxicity of chemical wastes that must be shipped off-site for disposal as hazardous waste. The US EPA has established a hierarchy of waste minimization approaches:

1. **Source reduction** (most desirable) — includes any activity that reduces or eliminates the generation of chemical waste at the source.
2. **Recycling** — includes using a waste material for another purpose, treating and reusing it in the same process, or reclaiming it for another process.
3. **Treatment** — includes elementary neutralization or another method that is conducted in the laboratory as part of an experimental or analytical procedure.

8.1.1 Interactive Teaching Software and Demonstration Videos

An alternative to handling and disposing hazardous chemicals is to show the reaction using instructional media. For example, if the dangers of performing a thermite reaction in class prevent your students from seeing this demonstration, you could show the reaction on video. Interactive CD-ROM software that can be used in a networking environment is now on the market and is appropriate for high school use. Videotapes and videodisks are also available to demonstrate chemical reactions. Some vendors for courseware and videos are included in the list of reference materials at the end of this chapter.

8.1.2 Chemical Tracking Software

Computer software programs have been developed to assist in the tracking of chemicals from the time of ordering to the time they are consumed or disposed of. Such software can keep track of inventory information, indicate when it's time to order more of a chemical, keep summaries of usage, keep track of where things are located in storage, and provide a variety of other useful tools.

One such program is the CHEMIS (Chemical Health and Environmental Management in Schools) program which has been made available through the State Fire Marshall's office for inclusion in this manual. A copy of the CHEMIS management system disc is included with this manual. Directions for installation and use of the software are found in the CHEMIS manual.

8.1.3 Recycling Chemicals
Whenever and wherever possible, chemicals should be recycled before they become "chemical waste". This can mean using cyclic experiments, where the product of one reaction becomes the starting materials for the next experiment. This can mean using chemicals from another lab when they are no longer needed, or it can mean exchanging or otherwise making chemicals available to other schools. See section 8.1.9 for information on shipping and transporting chemicals.

8.1.4 Substitutions of Non-toxic Substances
Where possible, substitutions should be made to minimize the hazards and disposal costs associated with using a chemical. The following list is an example of substitutions that can be made. The exact substitution will depend on the application. In selecting a substitute, select the chemical that has a higher TLV (threshold limit value) or PEL permissible exposure limit). You should keep in mind that reducing the toxicity by substituting chemicals does not necessarily make the substitute nonhazardous for disposal purposes.

Possible Substitutions for Toxic Chemicals

Toxic Chemicals Relatively Non-toxic Substitutes

Chloroform l,l,l-Trichloroethane
Carbon tetrachloride Tetrachloroethylene
1,4-Dioxane Tetrahydrofuran or 1,2-
Dimethoxyethane
Benzene Cyclohexane or Toluene
Xylene Toluene
2-Butanol n-Butyl alcohol
Lead chromate Copper carbonate
p-Dichlorobenzene p-Nitrotoluene or naphthalene or lauric
acid (for melting point determination)
Potassium Calcium
Dichromate/Sulfuric acid
mixture
Ordinary detergents
Trisodium phosphate Ordinary detergents
Alcoholic potassium
hydroxide
Ordinary detergents

8.1.5 Microscale Experiments
Microscale experiments can be used to reduce the amount of hazardous material required, thereby reducing the hazards encountered when working with the chemicals and reducing the disposal costs. Laboratory manuals and microscale equipment are available through many laboratory supply vendors and publishers. See section 4.1.1 for a discussion of microscale experiments.

8.1.6 Classroom Demonstrations
Another effective way to reduce hazards for students and reduce amounts of waste generated is to perform classroom demonstrations for a variety of more hazardous experiments rather than have each student carry out the experiment. Often this proves to be least hazardous for the student. See section 4.1.2 for safety guidelines for classroom

demonstrations.

8.1.7 Model Programs Developing Low Hazard Experiments

A group of graduate students at the University of Illinois at Urbana-Champaign has formed an organization, Encouraging Tomorrow's Chemists (ETC), which has developed a series of experiments that can be used in senior and junior high schools. The primary intent of these hands-on experiments is to "demystify" science. Experiments are one-to-two periods long and currently include the topics of polymers, luminescence, forensics, environmental chemistry, chemistry of life, and imaging chemistry. Since these experiments also serve to reduce the use of hazardous chemicals, most products from the experiments can be discarded in normal waste streams. The address to contact for more information is in the references at the end of this chapter.

The Rend Lake College Videolab/Kitchen Chemistry project was developed through a Dwight D. Eisenhower Mathematics and Science Education Grant administered by the Illinois Board of Higher Education. The module is a unique combination of interactive computer programs and "EPA safe" (i.e., waste may be poured down the drain) hands-on experiments that provides a rather complete and appropriate series of laboratory experiences. This model program reduces hazards, lowers costs, and increases instructional time by reducing set-up and clean-up time. The experiments are especially useful for high schools with limited financial resources and inadequate facilities. The address for more information is in the references at the end of the chapter.

Additional model programs can be considered for future editions of this guidebook submitting them to Gwen Pollock, Illinois State Board of Education, 100 North First Street, Springfield, IL 62777-0001.

8.1.8 Purchasing Chemicals

When purchasing chemicals, it is important to consider a variety of things beyond the immediate need for the chemical. CHEMIS has suggested asking the following six questions before purchasing a chemical:

1. Can proper storage be provided for this chemical?
2. Are facilities appropriate for the use of this chemical?
3. Will this chemical or end product need to be disposed of as hazardous waste?
4. Is adequate personal protective equipment available for the use of the product?
5. Have personnel who will handle and use this chemical been trained and are they aware of the hazards?
6. Is the quantity being ordered appropriate for the anticipated use? Asking for an MSDS from the company before purchasing the chemical may help to provide this information.

When ordering any chemical, **do not order a supply for greater than two years of use**. Remember to maintain a complete chemical inventory.

8.1.8.1 Container Sizes

Historically, there has been significant incentive to buy larger sizes of chemical containers because the unit cost of chemicals is generally much less. This justification may no longer be valid if one takes into account potential risks and disposal costs. Some reasons why chemicals should be purchased in small containers include:

1. Extended storage of unused chemicals increases the likelihood of breakage or leaks. Larger bottles tend to break more readily than smaller bottles, creating greater risks and costs associated with cleaning up spills. Accidents also increase negative publicity and legal liability.

2. Disposal costs are continuously escalating. As experiments and teachers change, stored chemicals may no longer be needed.
3. Smaller packages are emptied faster, which lessens the likelihood of decomposition or having chemicals go beyond their expiration dates.
4. Storage of large quantities results in higher costs, such as additional stockroom space and engineering measures to prevent and control fires and to increase ventilation.
5. Purchase of large quantities means that smaller "transfer" containers are required. This increases the likelihood that the small containers will be labeled improperly or that labels will be lost. According to the American Chemical Society's Task Force on Laboratory Waste Management, the cost of analysis of a small amount of an unknown can exceed $1000. They also suggest that disposal costs can easily surpass the purchase price, especially for wastes that are difficult to dispose of, such as those containing toxic metals or dioxin.

8.1.9 Shipping and Transporting Chemicals

If chemical exchanges are made between schools on public highways, it is important that all Department of Transportation guidelines be followed. The Illinois Department of Transportation Haz Mat Compliance Unit has provided a clarification of
the Hazardous Materials Regulations (49 CFR 171.8) of the United States Department of Transportation (US DOT).

The US DOT has indicated in a recent interpretation that "person" is defined in Section 171.8 as any legal entity that handles, transports, or offers hazardous materials for transport in "commerce" or "in the furtherance of commerce". Hazardous materials handled by government vehicles are not generally considered to be handled or transported "in commerce" or "in the furtherance of commerce" under that definition and are therefore not subject to the regulation. Based on this interpretation, the Illinois Department of Transportation does not consider elementary and secondary schools and their employees who handle or transport hazardous materials in school owned and operated vehicles, for school programs, to be operating "in commerce" or "in the furtherance of commerce" and therefore are not regulated. The interpretation issued by US DOT does state however, that governmental agencies are regulated when offering hazardous materials for transportation to a carrier operating "in commerce" or "in the furtherance of commerce". Therefore, when elementary or secondary school employees offer hazardous materials to a carrier operating "in commerce", the actions of those employees are regulated under the hazardous materials regulations. For example, if school employees were to offer waste chemicals to a carrier operating "in commerce" for transportation to a disposal facility, those employees would have to be properly trained on how to classify, describe, package, mark, label and offer hazardous materials for transportation.

8.1.10 Twenty-five Ideas to Help Reduce Your Hazardous Waste

The Chemical Waste Management section of the Division of Environmental Health and Safety at the University of Illinois at Urbana-Champaign (UIUC) has developed a list of ways to reduce hazardous waste in university research and teaching labs. Following are excerpts adapted for high school chemistry laboratories:
1. Evaluate experiments and demonstrations to see if less hazardous or nonhazardous reagents could be used.
2. Purchase chemicals in smallest quantities needed.

3. Date chemical containers when received so that older ones will be used first.
4. If possible, establish an area for central storage of chemicals.
5. Establish an area for chemical waste.
6. Write a waste management/reduction policy.
7. Inventory chemicals at least once a year.
8. Centralize purchasing of chemicals through one person in the school.
9. Include waste reduction as part of student training.
10. Use manuals such as the American Chemical Society (ACS) "Less is Better" or "ACS Waste Management for Lab Personnel" as part of your training. Label all chemical containers as to their content so that they don't become "unknowns".
11. Develop procedures to prevent and/or contain chemical spills: purchase or make spill clean-up kits, use secondary containment in areas where spills are likely.
12. Segregate your wastes to reduce volume and costs for disposal:

- Keep recyclable waste/excess chemicals separate from nonrecyclables.
- Keep nonhazardous chemical wastes separate from hazardous waste.
- Keep organic wastes separate from metal-containing or inorganic wastes.
- Keep halogenated solvents separate from nonhalogenated solvents.
- Keep highly toxic wastes (cyanides, etc.) separated from above.

13. Use the least-hazardous cleaning method for glassware. Use detergents such as Alconox, Micro, or Pierce RBS-35 on dirty equipment rather than/or before using KOH/ethanol bath, acid bath, or No Chromix.
14. Substitute red liquid (spirit-filled), bimetal, digital, or thermocouple thermometers for mercury thermometers where possible.
15. Avoid the use of reagents containing barium, arsenic, cadmium, chromium, lead, mercury, selenium, and silver.
16. Consider the quantity and type of waste produced when purchasing reagents.
17. Purchase equipment that enables the use of procedures that produce less waste.
18. Review your procedures regularly (e.g., annually) to see if quantities of chemicals and/or waste could be reduced.
19. Look into the possibility of including detoxification and/or waste neutralization steps in laboratory experiments.
20. Scale down experiments producing hazardous waste wherever possible.
21. Use preweighed or premeasured reagent packets where waste is high.
22. Encourage orderly and tidy behavior in the lab.
23. Be wary of chemical "gifts" from outside the school. Chemical gifts can very easily become your "hazardous waste."
24. Use demonstrations or video presentations to replace experiments that produce large amounts of hazardous waste.

8.2 Laboratory Waste Disposal

It is inevitable that some quantity of chemical waste will be generated as a result of teaching chemistry. Due to the problems, costs, and potential hazards associated with this chemical waste, it is strongly recommended to do everything possible to minimize the amount of waste generated (section 8.1). Chemical waste can be either hazardous or nonhazardous, with each type requiring different handling and disposal.

8.2.1 Hazardous Waste Defined

Wastes are classified by the EPA as hazardous if they are specifically listed in 35

IAC subtitle G part 721 subpart b or meet at least one of the following characteristics:

1. **Ignitable** — has a flash point of <140° F, is an oxidizer, or is an ignitable compressed gas;
2. **Corrosive** — has a pH ≤ 2.0 or a pH ≥ 12.5;
3. **Reactive** — is reactive with air or water, is explosive, or is a cyanide or sulfide;
4. **Toxic** — has certain levels of certain metals, solvents, or pesticides greater than prescribed limits. Non-hazardous wastes are all other chemical substances that are not covered under of these definitions.

8.2.2 Disposal Options

Small quantities of nonhazardous wastes can be disposed of in an approved special waste landfill, dissolved in water and flushed down the sanitary sewer, or handled as hazardous waste. Large quantities of nonhazardous chemicals may need to be handled by a professional contractor. Take care to avoid the appearance of a problem even though one may not actually exist. Examples of these problems would be throwing away vinegar and baking soda in the same waste container. If they mix, the result is a harmless but very visible reaction. Another common occurrence is the once-a-year storeroom cleanup. This activity generates large quantities of brown bottles with mysterious (to untrained personnel) powders in the trash dumpster. To those with chemophobia, the powders appear toxic. Properly disposing of even small quantities of hazardous waste becomes a more involved and costlier process. All hazardous wastes, except for neutralizable acids and bases and water soluble alcohols, must be handled by professional disposal contractors. The usual procedure involves the contractor placing a number of bottles in a pail or drum to create what is called a lab-pack. This lab-pack is then incinerated, buried in a hazardous waste permitted landfill, or sent for specialized treatment. The treatment method can easily cost several thousand dollars.

8.2. 3 Neutralization of Strong Acids and Bases

Neutralization is the most efficient and least costly way of managing waste acids and bases. The following procedure comes from the UIUC Waste Minimization Bulletin No. 10.3 As always, do not perform a procedure that you do not feel comfortable doing. After neutralization, waste liquids can be disposed of in a sanitary sewer.

Procedures for Neutralization of Strong Acids and Bases

A. Personal Protection and Equipment

Carry out neutralizations in a well-ventilated fume hood. Use the sash or a safety shield for protection against vigorous reactions. Wear an apron, splash-proof goggles, or a full-face shield and nitrile gloves. Long gloves or gauntlets are also recommended. A 5-gallon polyethylene bucket is recommended for neutralizing 1-10 liters. A large container is needed in acid neutralization for addition of ice and base and for stirring the reaction safely.

B. Solutions That Should Not Be Neutralized

The solution you plan to neutralize should not contain heavy metals such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Wastes containing high levels of other metals may be of concern as well. Your local sanitary district can tell you if these wastes can be neutralized and sewered. Acids that are very reactive with water should not be neutralized unless you are expert in handling and using these acids. These include: acid anhydrides and chlorides; chlorosulfonic acid, fuming nitric and sulfuric acids; liquid halides of boron, silicon, tin, titanium, and vanadium; and liquid halides and oxyhalides of phosphorus, selenium, and sulfur. Hydrofluoric acid is also very dangerous and should not be neutralized unless you are an expert handling it and know what you are doing.

C. Procedures — Neutralization of strong bases Bases that may be neutralized include: solutions of potassium and sodium hydroxides, alcoholic sodium or potassium hydroxide cleaning solutions, ammonium hydroxide and ammonia solutions.

1. Dilute the base to a 5% (by weight) concentration or less.
2. Slowly add 6 N hydrochloric acid or other acid.
3. Monitor pH changes with pH meter or pH paper. (Note: Liquid indicators can oxidize rapidly in basic solutions and give false color change).
4. When pH is between 6 and 10, solution can be washed down sanitary sewer with 20 parts water.

D. PROCEDURES - Neutralization of strong acids

1. Prepare a 6 N solution of sodium hydroxide (240 grams/liter of water) or potassium hydroxide (336 grams/liter of water).
2. One liter of 6 N base can neutralize:

Acid Quantity in ml Acid Quantity in ml
Acetic acid (glacial) 342 Nitric acid (70%) 378
Formic acid (88%) 264 Perchloric acid (70%) 516
Hydrochloric acid
(37%)
504 Phosphoric acid
(85%)
414
Hydrobromic acid
(48%)
720 Sulfuric acid (96%) 166
Hydriodic acid (47%) 1080 Trichloroacetic acid
(20% solution)
4902

3. Dilute the acid to a 5% (by weight) concentration or less (add acid to water, **not** water to acid). Use ice as necessary to cool the solution. Limit the solution to a maximum of 10 liters. Acids that may generate heat upon neutralization are phosphoric and sulfuric acids.
4. Neutralize with 6 N sodium hydroxide or potassium hydroxide, adding it slowly.
5. Monitor pH with pH paper, a pH meter, or a suitable indicator.
6. When pH is between 6 and 10, wash solution down the sanitary sewer using 20 parts water.

8.2.4 Disposing of Laboratory Waste Using the Sanitary Sewer System 1

It is important to realize that sewage disposal plants vary by location in capability and the type of operation they carry out. The information presented here is a summary of what is generally accepted in present literature. As disposal plants vary, so will their ability and willingness to accept various laboratory or other wastes in the wastewater stream. Laboratory wastes should never be dumped into a drain that leads to a septic system. Modest quantities of many common laboratory chemicals can be disposed of through the sanitary sewer system if local regulations and plant operator approve. Check with your local treatment plant operator to find out exactly what is acceptable and what is not because treatment facilities also have varying regulations governing their activities. The inquiry should include the specific disposal precautions that the school proposes to take and the applicable material safety data sheet (MSDS). If possible, verify acceptable wastes in writing. Contacting and securing written permission by the local officials does not exempt the school from any local, state, and/or USEPA enforcement if the waste discharged causes a problem in the collection system or at the waste water treatment plant.

The following precautions should always be used:

- Use a drain that empties into a wastewater treatment facility, not a storm drain, combination (sanitary and storm) sewer, or other drain that flows untreated into surface water. It is likely that such drainage directly into surface waters would be in violation of the Clean Water Act (CWA) or Storm Water Regulations.

- Limit quantities of chemicals to a few hundred grams or milliliters. Do not use drains for large quantities.

- Dispose of only soluble wastes and dilute at least 1000-fold with water at the drain.

- All acids and bases should be neutralized before disposal in the sewer system. Check pH level before disposal. Note: some regulatory agencies consider neutralization as treatment and require obtaining separate, most of which are very time consuming and expensive.

- Remember: **Some** chemicals may be disposed of by using the sewer system, but **most** may not.

8.3 Resources

ETC Program
University of Illinois at Urbana-Champaign
Box 90-5, Roger Adams Laboratory
S. Mathews
Urbana, IL 61801

Rend Lake College Videolab/Kitchen Chemistry Project
Dr. John Fisher
Rend Lake Community College
Ina, IL 62846
437-5321

Hazardous Waste Resource and Information Center
Woodfield Drive
Savoy, IL 61874

Illinois Department of Transportation
Terrence Moore
HAZ MAT Compliance Unit
Division of Traffic Safety
Executive Park Drive
Springfield, IL 62794-9212

Illinois EPA

Emergency Response Unit
Churchill Road
Springfield, IL 62706
8-14
US EPA
Region 5
Waste Management Division
S. Dearborn Street
Chicago, IL 60604
Office of the State Fire Marshall
Stevenson Dr.
Springfield, IL 62703-4259
Some Vendors of Instruction Software and Videos
American Chemical Society
1155 16th. St. N.W.
Washington, D.C. 20036
800-227-5558
Falcon Software, Inc.
Box 200
Wentworth, NH 03282
603-764-5788
Journal of Chemical Education Software
Department of Chemistry
1101 University Avenue
University of Wisconsin-Madison
Madison, WI 53706-1396
608-262-1483
Trinity Software
P. O. Box 960 Campton, NH 03223
1-800-352-1282

8.4 References

1. CHEMIS. 1994. *Chemical Health & Environmental Management in Schools-Systems Management Manual*. Independence, MO: Pan-Educational Institute

2. Task Force on Laboratory Waste Management. 1993. *Less is Better*, p. 5. Washington, D.C.: American Chemical Society

3. University of Illinois at Urbana-Champaign Division of Environmental Health and Safety. 1995. Neutralization of Strong Acids and Bases. *Waste Minimization Bulletin #10*

Chapter 9
Standard Operating Procedures
9. 1 Laboratory Equipment
9.1.1 Glassware
Students in science labs use several types of glassware. In a study of accidents in academic chemistry laboratories, 54% of the accidents examined involved glass beakers, glass tubing, rods or thermometers.[1] The most frequent injurious activity involved assembling equipment, especially inserting glass tubing into rubber stoppers. Cuts and burns from glass are the most common injury in school laboratories. In the 1986 study, 62% of the accidents reported were lacerations and 35% were burns.[1] Glassware is used for:

1. measuring volume:
pipets
graduated cylinders
medicine droppers
volumetric flasks
burets
2. storing solids and liquids:
bottles and vials
3. containing reactive chemicals during experiments:
beakers
flasks
test tubes
watch glasses
test plates
stirring rods
4. transferring liquids and gases
glass tubing
funnels
5. measuring temperature
thermometers

2

Rules for Using Glassware

Each type of glassware has its proper use and should be used only for its intended purpose. A summary of some rules for using glassware is listed below. More detailed explanations of each rule follow.

Summary of Rules for Using Glassware

1. Use glassware only for its intended use.
2. Use glassware that is without defect.
3. Use proper disposal procedures.
4. Use the correct kind of glass.
5. Use care when working with hot glass.
6. Use glass bottles for storing chemicals that are compatible with the glass.
7. Keep glassware clean.
8. Be careful with glassware that is “frozen.”

9. Use gloves or towels to protect hands when breaking glass tubing. Wear goggles to protect eyes.

Detailed Rules for Using Glassware

1. Use glassware only for its intended use.

For example:

- do not use burets and volumetric flasks to store solutions;
- do not use beakers to measure volume.

2. Use glassware that is without defect.

Glass breaks easily and broken glass has sharp edges. The most common injury involving glass is a cut. Cuts occur when a student is not careful with broken glass or glass breaks as a student is using it. Glassware should have:

- smooth edges. You can smooth edges of glass tubing by fire polishing.
- no cracks or chips. Be particularly watchful for star-cracks in beakers and flasks. These usually appear at the bottom of the flask. Dispose ofcracked glassware properly.

3. Use proper disposal procedures.

- dispose of properly: Do not put broken glass in the general trash barrel or waste basket. Use a thick-walled cardboard, plastic, or ceramic container lined with a very tough plastic bag so custodians can remove the liner without handling the broken glass. Clearly label the container "**BROKEN GLASS ONLY**".
- thick gloves: Wear cut-resistant gloves when handling broken glass or use a broom and dustpan. Do not pick up broken glass in your bare hands.

4. Use the correct kind of glass.

Usually, beakers and flasks are made of borosilicate glass (Pyrex® brand or Kimax® brand), a type of glass that is resistant to breaking when heated or cooled. This is not true for common glass. Common glass breaks easily with thermal shock.

Only use borosilicate glass when heating is required. If you use test tubes, beakers or flasks for heating liquids or solids, make sure the Pyrex® or Kimax® label is on the glassware. Note that test tubes are not always made of borosilicate glass. Do not use bottles, vials, or volumetric flasks for heating.

Remember, however, that borosilicate glass only resists thermal shock. Even a Pyrex® beaker will break if cold water is poured into a hot beaker.

5. Use care when working with hot glass.

Hot glass looks the same as room temperature glass. Therefore, do not leave hot glassware unattended, and allow ample time for the glass to cool before touching.

Check the temperature of the glassware by placing your hand near, but not touching, the potentially hot object. Have hot pads, thick gloves, or beaker tongs available for grasping hot glassware.

6. Use glass bottles for storing chemicals that are compatible with the glass. Most solutions containing water and almost all organic chemicals are compatible with glass. The most common materials used in science labs that are incompatible with glass are solutions of hydroxides and carbonates. These chemicals slowly etch glass. Glass can be used for short-term storage of such chemicals, but plastic containers should be used for longer storage. The tops for reagent bottles containing corrosive chemicals should be plastic.

7. Keep glassware clean.

- Clean immediately after use. The longer glassware sits, the harder it is to clean.
- Use detergent (such as dishwashing powder for dishwashers) to help in cleaning. Be sure to rinse the glassware well. It is good practice to rinse the glassware with distilled water and then let it drain to dry.
- Chromate solutions are dangerous to use and harmful to pour down the sink. Under no circumstances should chromate solutions be used in schools.
- If you use brushes for cleaning glassware, make sure the metal part of the brush does not scratch the glass.
- Ultrasonic cleaners can often help clean dirt out of small crevices.

8. Be careful with glassware that is "frozen".

Here are some common situations of "frozen" glassware:

- nested beakers that have jammed together
- stoppers that cannot be removed from bottles
- stopcocks that cannot be moved

Only teachers should try to release the frozen area. Teachers should use gloves and goggles while doing so. Heating the outside glass and letting paraffin run between the frozen parts will sometimes help free stoppers from bottles. Frozen nested beakers can be released by carefully squeezing the largest beaker on the side perpendicular to the lip of the inner beaker. If all else fails, discard it.

9. Use gloves or toweling to protect hands when breaking glass tubing. Wear goggles to protect eyes.

Learn the proper technique for breaking tubing. Always fire-polish the ends before using.

- Scratch the glass with a file or score.
- Wrap the glass in a towel.
- Place the thumbs together opposite the scratch.
- Pull and bend in one quick motion.
- Fire polish the broken ends.

9.1.2 Corks and Stoppers

Corks and rubber stoppers are commonly used to seal glassware. Use corks for sealing organic solvents and rubber stoppers for sealing aqueous solutions. Often thermometers and glass tubing are inserted through the cork or stopper. In schools, only teachers should do this and then with great caution. Dreadful accidents can occur when students either insert or remove tubing or thermometers from stoppers, and the tubing or thermometer breaks.

To insert glass tubing or a thermometer into a cork or stopper:

- protect your hands with leather gloves;
- check that the hole is the correct size;
- lubricate the hole before inserting thermometers or tubing. Use glycerin or soapy water;
- hold the glass close to the stopper and keep this distance short;
- use a rotary motion to guide the glass through the stopper;
- remove thermometers immediately after use. If they are difficult to remove, carefully cut away the cork or stopper.

9.1.3 Thermometers

Most students have experience with fever thermometers, not laboratory thermometers. As a result, someone will try to “shake it down” before using. Students must be told specifically not to do this. There are a variety of ways to measure temperature, including: thermometers, thermocouples, resistance thermometers. Consider using resistance thermometers (thermal probes) as an alternative to glass thermometers. Many of these can be interfaced easily to computers or pH meters. Alcohol thermometers are **strongly** recommended in place of mercury thermometers for many school experiments. If mercury thermometers are used for their greater accuracy, Teflon® coated thermometers are available. Consider purchasing antiroll thermometers.

Rules for Using Thermometers

- Do not use thermometers as a stirring device.
- Never swing or shake down a thermometer.
- Never use an open flame on a thermometer bulb.
- Use extreme care when inserting or removing a thermometer from a rubber stopper.
- Mercury thermometers should not be used in heated ovens where breakage might easily occur. If thermometers are broken, the mercury is difficult to clean from the ovens, and the elevated temperatures can produce significant mercury vapors. Metalstemmed thermometers should be substituted.

9.1.4 Mercury Handling

Mercury vaporizes rapidly, is readily absorbed, is very poisonous, and is difficult to clean up. **Minimize or even avoid the use of mercury in school laboratories**. Do not do the old Torricelli experiment of making your own barometer. Do not let students make silver coins by placing them in mercury. Do not do experiments with mercury salts. None of these are worth the risks. If you use mercury for any purpose, you should have a spill kit available. These can be purchased from lab safety suppliers. The common practice of using powdered sulfur to pick up mercury dropletts is not reliable. Powdered zinc can be used to dust surfaces, but the mercury sponge available in kits is best.

9.1.5 Pipetting

Pipets are convenient for measuring and dispensing volumes of liquids and come in a variety of types and sizes. These include:

Use volumetric and graduated pipets that are designed to deliver . They will be stamped with a TD label on the stem   Since pipets look a lot like straws, student have a tendency to try to use them likestraws. Therefore strict rules are necessary:

- **volumetric pipets** (a) — pipets that dispense a fixed volume of liquid
- **graduated pipets** (b) — pipets with graduations along the side. These dispense a variable amount of liquid. Graduated pipets are available in glass or plastic.
- **Pasteur pipets** (c) — disposable glass or plastic pipets for measuring drops (an eye dropper is a variety of Pasteur pipet). The plastic sealed eye droppers are particularly nice to use in school settings partly for safety reasons and partly because they have interesting uses in microscale chemistry.

Using a Pipet

(a) (b)

- Never put a pipet in your mouth.

- Draw the liquid into the pipet using a rubber bulb. For volumetric or graduated pipets, use a rubber bulb that creates only temporary contact with the opening of the pipet to create a suction that draws the liquid into the pipet (a).
- Remove the bulb and place your index finger over the pipet opening to stop the flow of liquid (b).
- Carefully raise your finger slightly to allow the pipet to drain under your control.
- Never withdraw a liquid from a near-empty container. If you attempt to fill a pipet under conditions where air can enter the pipet, the liquid will shoot up into the rubber bulb uncontrollably.
- Never lay a pipet flat on a table or turn upside down with the rubber bulb attached. The liquid will flow into the rubber bulb, contaminating the bulb and the pipet.
- Dispose of broken glass pipets in an appropriate glass-disposal box

9.1.6 Heat Sources

The Bunsen burner is being replaced in many school labs. Hot plates are a much better substitute for providing heat. Alcohol burners are dangerous and should be used only if no other source is available.

Using an Electric Hot Plate

- Use a smooth surface hot plate
- Cover the surface with aluminum foil for easy cleaning
- Hot plates look the same hot as cool. Always assume they are hot.

9.1.7 Dispensing Chemicals

Material Safety Data Sheets (MSDSs) are the most complete sources of information about the physical and chemical properties, the health and fire hazards, spill procedures, handling procedures, and first aid for any substance (section 4.1.6). No chemical should be used or handled until the label and MSDS have been read and understood. **The teacher has the responsibility for instructing students about safe methods for working with chemicals**.

- Use the smallest amount of chemical possible in any experiment. Microscale is a method of reducing the amount of chemicals used in an experiment. It is safer, it is economical, it produces less waste and requires less storage space. Even if you do not use microscale, try to use smaller quantities (section 4.1.1)..

Using a Bunsen burner

- Make sure you know the location of the master gas shutoff valve.
- Match the type of burner to the type of gas available.
- Use lighters. They are safer than matches for lighting burners.
- Make sure all students know how to operate the burner safely.
- Make sure there are no leaks in rubber hoses connecting the source to the burner.
- Keep rubber hoses away from the flame.

- Consider having the instructor dispense the amount of chemical for an experiment into vials for each student. This will minimize waste and save time during the class period. The best practice for weighing samples is to weigh a vial containing the chemical, pour the sample from the vial into a reaction vessel, then reweigh the bottle. When students weigh chemicals directly on balances, it wastes time and causes cleanup problems.

- Use proper containers for dispensing solids and liquids. Solids should be contained in wide-mouth bottles and liquids in containers that have dripproof lips. The containers should be labeled properly. Student should be taught to remove glass stoppers with the backs of their hands, hold the bottle with the label in their palms, and clean up any spills.

- Do not return dispensed chemicals to stock bottles. This invites contamination despite your best precautions.

9.1.8 Vacuum

The dangers of systems under vacuum are similar to those under excessive pressure. (The destruction created by a tornado is really due to vacuum) Containers that have been evacuated will implode rather than explode. Since a vacuum is more commonly created in glass containers, the implosion hazard creates the possibility of flying glass. We create vacuum in the lab with pumps and aspirators. We can also create vacuums (either intentionally or accidentally) by condensing vapors in a closed system. The familiar demonstration of crushing a soda can by heating water in the can to change it to steam and then cooling the can after sealing the top is a dramatic example of the effects of a vacuum.

- Place guards around glass containers in which a vacuum might be created. Plastic electrical tape works well. Do not tape vacuum equipment so thoroughly that impairs visibility. If a container is repeatedly used to contain a vacuum (like a vacuum desiccator), you may purchase an appropriate shield.

- Always design a relief system into vacuum systems. This can often be a stopcock or an unused Bunsen burner, something that slowly bleeds air into a system under vacuum.

- Avoid reactions or experimental procedures in closed systems For example, make sure that distillation setups have some part that is open to the air or to a vacuum relief system.

- Properly handle and maintain vacuum pumps
  - Change the oil on a regular basis
  - Always have a trap attached
  - Have belt guards around belts and pulleys

9.1.9 Centrifuges

Centrifuges can be dangerous because the rotor develops considerable force.

- Make sure the centrifuge operates vibration-free up to the top speed.
- Position test tubes opposite each other with the same weight of material in each tube. Out of balance centrifuges can “walk” off the table.
- Never leave a centrifuge running unattended.
- Keep rotors and buckets clean.
- Do not try to stop the centrifuge by grabbing it. Make sure the centrifuge is completely stopped before removing tubes from it.

9.1.10 Cryogenics

Working with dry ice and liquid nitrogen can be educational, but both are dangerous and should be handled only by the teacher. Liquid nitrogen requires special flasks for storage. These will break easily if handled carelessly. Use goggles at a minimum (complete face shield is better), thick gloves, and long sleeves when working with either of these substances. It is very important that students observing demonstrations with cryogenics have eye protection and be seated at a safe distance from the demonstration.

9.1.11 Compressed Gases

Compressing a gas allows a lot of matter to exist in a small container. When compressed, a normally safe gas (like nitrogen or air) becomes a great safety risk. **A gas cylinder could behave like a bullet if improperly handled!**

- Have available proper carts for transporting cylinders. Do not roll large cylinders around.

- Use the proper tank and fittings designed for each gas. Your gas supplier will be able to help you with this.

- Always use compressed gases in a well-ventilated area. Asphyxiation is the most subtle danger of working with compressed gases. You should anticipate that leaks will occur and that the release of any gas in an enclosed space will lower the amount of available oxygen in the air. Special dangers are possible if flammable or toxic gases are used.

- Always make tanks secure. No compressed gas tank should be allowed to stand free. Strap or tightly chain full or empty tanks to rigid support to prevent accidental toppling of the tank.

- Keep electrical lines free from compressed gas tanks.

- Keep gas tanks away from heat sources.

9.1.12 Batteries and Electrical Equipment

Use low current, low voltage sources whenever possible. Alkaline or dry cell batteries are safest for use in the classroom.

- Avoid lead storage batteries since they contain concentrated sulfuric acid and can emit explosive hydrogen gas when recharged.
- Dispose of all spent and leaking batteries properly.
- Do not try to recharge batteries unless they are specifically designed for recharge.
- Do not try to heat a battery.
- Store batteries in a refrigerator.
- Avoid using apparatus (such as a conductivity tester) that connect directly into the 110v line.
- Ground all electrical outlets. Consider having a qualified electrician check the circuits. Any outlet within 6 feet of a water source should be equipped with a ground fault interrupter.
- Provide every science classroom with a master shut-off switch for electricity
- Label all live switches and circuits clearly.

• Make sure students' hands and work areas are dry before letting them use electrical devices.
• Check all circuits before the power is turned on.
• Connect the live portion last and disconnect it first when assembling circuits.
• ground all electrical equipment.
• Avoid using extension cords.
• Tape cords to table legs if possible. This will help absorb the force of a pull in case a person trips over the cord.
• Inspect equipment regularly for wear and damage.
• Stop using any electrical equipment that is working erratically.

9.1.13 Lasers

Many types of lasers are available including ones that are sold as pointers. The high intensity beam of a laser is especially harmful to eyes. When using a laser:

- make sure you read the safety rules and operating instructions for the laser you are using;
- use laser goggles;
- make sure that the laser beam is never pointed at anyone;
- check your experimental setup by marking the paths of intense laser light;
- anticipate and examine projected light paths before adding or removing optical components;
- remove all reflective jewelry before working with lasers;
- never view either the direct or reflected beams;
- keep the laser beam at or below chest height;
- never leave the laser unattended;
- block off the beam past the target.

9.2 Safety Committees and Inspections

A safety committee should be instituted for each school and should include faculty, school nurse, administrators, and students. Custodians and faculty from fine arts and industrial arts programs should be included.The committee would be responsible for formulating and assessing compliance with safety regulations. The responsibilities of the safety committee are to:

- encourage safe practice throughout the school;
- know proper emergency responses;
- collect and maintain material safety data sheets and a safety library;
- conduct safety audits and regular inspections of laboratories to make sure safety equipment is present and is maintained, including flushing eye wash stations and checking fire extinguishers;
- verify whether or not rules and procedures are being followed;
- act as a clearing center for reporting dangerous activities or situations;
- enforce proper storage and handling of hazardous materials.

9.3 References

1. Hellmann, M. A., Savage, E. P., Keefe, T. J. 1986. Epidemiology of Accidents in Academic Chemistry Laboratories. *J. Chem. Educ.* 63:A267-70; A290-293

Chapter 10
Other Special Considerations
10.1 Outside Project Safety

Projects, whenever possible, should be conducted under teacher supervision in the school laboratory setting. This will ensure proper supervision and the proper safety equipment on hand.

Chemicals from the school laboratory and storeroom should not be loaned out from these locations.

The assignment of outside independent projects must be in line with the age, ability, and expertise of the individual student. What is appropriate for an advanced placement chemistry

student would probably not be appropriate for a freshman. Every consideration should be to the safety of the student involved as well as those in the nearby environment. All electrical, chemical, biological, and environmental safety considerations need to be addressed. Approval of any outside project should be dependent on these considerations. At times, experts in the community, such as scientists, doctors, technicians, and engineers may serve as supervisors.

Parents may be included if they are totally familiar with every safety consideration.

As in all experiments, prudent practices must be followed. The teacher cannot anticipate or regulate laboratories that are set up in the home, but the teacher can approve the methodology and safety considerations of all experiments required or encouraged for a particular course or extra activity. The teacher should review the procedure, make suggestions, and point out any possible safety problems inherent in the design.

The Illinois Junior Academy of Science has established a set of safety rules for students participating in science fairs sponsored by the academy. All projects should be conduced only with proper supervision. The following rules are useful guides for all outside projects: -DRAFT-2/15/00

Illinois Junior Academy of Science Project Safety Rules

a. Chemical

1. Students should always wear eye protection when working with any chemical.
2. The student and the sponsor should review data from a textbook, Merk Index, or other responsible source regarding the health hazards, combustibility, and compatibility of the chemical with other chemicals before beginning a project.
3. All chemicals must be disposed of in accordance with state and federal environmental rules and regulations.
4. If possible, the student should work under the supervision of a responsible chemist.

b. Fire and Radiation

1. Students should always wear eye protection when working with any open flame.
2. Students using radiation sources (laser, U-V light, X-ray, microwaves, or high intensity radio waves [RF]) must be adequately shielded form these sources. Many experiments using these sources should not be undertaken unless under the direct supervision of an adult familiar with the equipment and hazards involved.
3. No student may work with any radioactive materials unless the work is conducted in a licensed laboratory under the direct supervision of a licensed individual.

c. Electrical and Mechanical

1. All electrical apparatus that operates with 115 volt current must be constructed in accordance with the National Electrical Code (NEC). If in doubt, contact a competent electrician.
2. Many experiments can be done using 6 or 12 volt electrical sources. As these are much safer electrical sources, their use should be considered when doing a project.

d. Biological Cultures

1. The greatest safe-guard when working with microorganisms of any kind is the use of sterile technique. This technique should be learned under proper supervision before beginning any project involving micro-organisms.
2. No cultures taken from human or other warm blooded animals may be used in any project because of the danger from unknown viruses or other disease causing agents that may be present. Pure cultures of micro-organisms known to inhabit warm-blooded animals may be purchased from reputable supply houses and used.

3. No wild cultures may be incubated above room temperature (65 to 75 degrees F, 18.3 to 23.9 degrees C).
4. Projects involving viruses must be done in a professional research facility under the direct supervision of a professional researcher.
5. Recombinant DNA projects must be done with the help of a research professional trained in recombinant DNA methodology and must comply with the National Institutes of Health (NIH) Guidelines unless the project is limited to a kit obtained from a legitimate supply house.
6. All cultures are to be killed by autoclaving or with a suitable NaOCl (bleach) solution before disposal.

10.2 Radioisotope Use

10.2.1 Hazards and Detection of Radiation

Radioisotopes are radioactive chemicals that contain atoms whose nuclei are unstable. They are capable of spontaneously emitting alpha particles, beta particles, and gamma rays.

Radioactivity can be detected by methods such as:

- electroscopes
- Geiger: Mueller tubes
- liquid and crystal scintillators
- NaI doped with thallium. They work like a T.V. screen and convert the energy of alpha, beta, and gamma radiation and X-rays into light.
- film badges
- thermoluminescence detectors. They are 3 mm x 3 mm chips of LiF and inorganic salts that trap and store photons that are released as light when heated.
- proportional counters

Radiation shielding can be accomplished in several ways:

- Alpha particles are stopped by a sheet of paper or the skin. **They are extremely hazard if ingested or inhaled.**

- Beta radiation is stopped by a sheet of aluminum. **They are extremely hazardous if ingested or inhaled**

- Gamma rays are stopped by a lead block**. They pose health hazards both internally and externally**.

Get medical help immediately if ingestion or inhalation of radioactive materials occur there is an excessive exposure to radiation. Most schools will have radioactive sources that are supplied to schools under general license by various manufacturers. These isotopes have low activity levels and are considered safe to handle with minimal precautions. Film badges would not be necessary when handling license exempt quantities of radioactive isotopes. These quantities of isotopes will be under the microcurie range.

10.2.2 Handling Radioactive Isotopes

1. Sealed sources are most convenient and should be chosen over liquid solutions.
2. When working with liquids or solutions, work over a tray lined with absorbent material backed by a nonporous material, such as waxed paper. The work area and the tray should also be lined in case of a spill.
3. All radioisotopes should be labeled "**Radioactive**" with information as to the level of radioactivity, date of assay, kind of radiation, and quantity of radiation.
4. The radioisotopes should be stored in a locked cabinet that is marked “**Radioactive Material**”.
5. When handling unsealed radioisotopes, wear rubber gloves. Handle solid material with tongs or forceps. Wash your hands after each use and check your hands with the proper type of instrument for measuring the radiation emitted by the source. In many cases, a Geiger counter will be sufficient.
6. Radioactive waste should be kept in a container designated for that purpose. Waste should not be allowed to accumulate. See disposal methods in section 10.2.3.

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7. General safety rules of the chemical laboratory also apply to the use of radioisotopes.

- Do not pipette liquids by mouth.
- Wear proper eye protection.
- Do not permit eating and drinking or use of cosmetics in the area of radioactive isotopes.
- Do not allow radioisotopes near the mouth, eyes, or open cuts and sores.
- Reactions should be performed in a fume hood to avoid any inhalation.
- Check all radioactive sources brought into the laboratory to be certain that the radiation emitted is not at a dangerous level.

10.2.3 Decontamination of Low Level Spills

1. Coat skin with TiO2/Lanolin mixture. Wipe off after one minute. Check area with survey meter. Repeat if necessary or gently rub skin area with a soft brush containing soap and water.
2. Wash work area with solutions of EDTA, sodium citrate, or sodium oxalate.
3. Wash stubborn contaminates with **dilute** inorganic acids or organic solvents. Do not use acid with 14C or 131I. These are supplied as a carbonate and sodium iodide respectively and will react with an acid to produce a radioactive gas.
4. Wash clothing with detergent and water. Rinse well.
5. Clean glassware and sinks with a strong laboratory detergent. Use plenty of water for rinsing. If glassware cannot be decontaminated, throw it away as radioactive waste.

10.3.4 Disposal of Radioisotopes

Disposal of small amounts of radioisotopes in the microcurie range can be handled as follows:

1. Solutions may be diluted with large amounts of water and flushed down the drain.
2. Solid materials and trash may be incinerated in a well-ventilated area.
3. If your school has its own septic system option 2 is recommended.

For disposal of radioisotopes with radiation levels above the microcurie level, schools must follow the Nuclear Regulatory Commission guidelines for disposal. These highly active wastes will require a complicated set of disposal techniques. Highly active waste will require the hiring of an outside contractor for disposal.

10.3 Other Radiation Sources

Any device that uses an electron beam, such as a cathode ray tube, is capable of producing X-rays. Three types of cathode ray tubes can produce potentially hazardous X-rays.

1. **Heat effect tube** — demonstrates that cathode rays are moving electrons where kinetic energy can be converted to heat energy.
2. **Deflection tube** — demonstrates that cathode rays carry an electrical charge and can be deflected by a magnet.
3. **Crooke's Tube** — demonstrates that cathode rays may be converted into visible radiation by fluorescence of the glass wall of the tube.

Recommended procedures when using these types of tubes:

1. These tubes should be used only for demonstration by the instructor and not by students.
2. Operate these tubes at the lowest possible current and voltage and for the minimum time to show the demonstration effectively.
3. Students should be at least eight feet from the operating cathode ray tube.

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Spectrum tubes are also sources of radiation. Use only UL approved energy sources to operate these tubes. These tubes, if operated at high current and voltage, can produce radiation in the ultra-violet or X-ray range. Operate for the minimum time for effective demonstration.

Ultraviolet light sources have inherent hazards that you need to be aware of. Radiation under 350 nm should be considered dangerous to both eyes and skin. Protective glasses with ultraviolet-absorbing lenses should be worn so that wavelengths below 350 nm will not be absorbed if produced accidentally. Everyone working near the source should have this eye protection. Long sleeves should be worn to protect skin areas. A second hazard associated with ultraviolet sources concerns the shelf life of the source itself. Ultraviolet sources will develop a hazardous buildup of ultraviolet absorbing films on the interior of any mercury arc lamp. At the end of the useful life of these lamps, the films cause the temperature to rise above the safe operating point. These sources should have running times recorded by the users so they can be discarded at the appropriate time. Check manufacturers specifications for the life of these sources.

Mercury spectrum tubes should be used with the same precautions.

10.4 Resources

1. Gerlovich, Jack and Downs, Gary. 1981. *Better Science Through Safety*, Iowa Sate University
Press, Ames Iowa
2. *Safety First in Science Teaching*, 1977. North Carolina Department of Public Instruction,
Division of Science.
3. *Safety in Academic Chemistry Laboratories*, 1979. A publication of the American Chemical
Society.

For Information of Nuclear Safety
Illinois Department of Nuclear Safety
1035 Outer Park Drive
Springfield, IL
217-785-9900

Chapter 11
Resources for a Safety Library
11.1 Addresses of Professional Associations:
American Association of Industrial Nurses
79 Madison Avenue
New York, NY 10016

American Chemical Society
1155 16th Street N.W.
Washington, DC 20036

American Conference of Governmental Industrial Hygienists
P.O. Box 1937
Cincinnati, OH 45201

American National Red Cross Safety Services
17th and D Streets, N W
Washington, DC 20006

American National Standards Institute
11 West 42nd Street
New York, NY 10036
212-642-4900

American Public Health Association
1015 15th Street, N.W.
Washington, DC 20005
202-789-5600

American Society for Testing and Materials
1916 Race Street
Philadelphia, PA19103
215-299-5400

American Society of Safety Engineers
1800 E. Oakton St.
Des Plaines, IL 60018
708-692-4121

Industrial Safety Equipment Association
2425 Wilson Boulevard
Arlington, VA 22201

Manufacturing Chemists' Association
1825 Connecticut Avenue, N.W.
Washington, DC 20009

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
1-800-344-3555

National Safety Council
1121 Spring Lake Dr.
Itasca, IL 60143
800-621-7615

National Science Teachers' Association
1742 Connecticut Ave., N.W.
Washington, DC 20009

National Society for the Prevention of Blindness
79 Madison Avenue
New York, NY, 10016

Scientific Apparatus Makers Association
1101 16th. St. , NW Suite 300
Washington, DC 20036
202-223-1360

Underwriters Laboratories, Inc.
333 Pfingsten Rd.
Northbrook, IL 60062
708-272-8800

11.2 References

References that are listed at a cost will need to be checked for availability and the cost of the material at the present time.

Aldrich Chemical Company Catalogue. Aldrich Chemical Company, 940 West St. Paul Avenue, Milwaukee, WI 53233.

Better Science Through Safety, Jack Gerlovich and Gary Downs, The Iowa State University Press, Ames, IA 50010.

Chemical Safety Data Sheets, and other publications including *Chem- Cards*, *and Water Information Cards* Manufacturing Chemists Association, 1825 Connecticut Avenue, N.W., Washington, DC.

CRC Handbook of Laboratory Safety, Newest Edition. Chemical Rubber Company, Cleveland, OH. (Cost)

Dangerous Properties of Industrial Materials, N. Irving Sax, Reinhold, New York, NY.

Flinn Chemical Catalog and Reference Manual, P.O. Box 219, 131 Flinn Street, Batavia, IL 60510.

Fisher Safety Manual, Fisher Scientific Company, 711 Forbes Ave, Pittsburgh, PA., 15219.

Guidelines and Recommendations for the Teaching of High School Chemistry, ACS Task

Force, American Chemical Society, 1984.
Health and Safety Guidelines For Chemistry Teachers, Reese, Kenneth; 1979, Department of Educational Activities, American Chemical Society, 1155 Sixteenth Street, N.W. Washington, DC 20036.
Hygienic Guides for Chemicals and Related Substances, American Industrial Hygiene Association, 14125 Provost, Detroit, MI.
Improving Safety in the Chemical; Laboratory: A Practical Guide, Jay A. Young, ed., John Wiley and Sons, New York, NY 1987.
Industrial Safety Data Sheets and Chemical Safety Guides, National Safety Council, Chicago, IL. (Cost)
"Is Your Laboratory A Safe Place To Work?", Lab Safety Supply Company, P.O. Box 1363, Janesville, WI 53545.
Laboratory Safety Checklist, Lab Safety Supply Co., P.O. Box 1363, Janesville, WI 53545.
Laboratory Safety Guidelines: 38 Suggestions for Improving Laboratory Safety, Dow Chemical Company, Recruiting and College Relations, Box 1713, Midland, MI 48640.
Laboratory Waste Disposal Manual, New Edition, Manufacturing Chemists Association, 1825 Connecticut Ave., Washington, DC 20009. (Cost)
Laboratory Waste Management: A Guidebook, ACS Taskforce on Laboratory Waste Management, American Chemical Society, 1155 Sixteenth Street, N.W. Washington, DC 20036, 1994.
Less is Better, American Chemical Society, 1155 16th Street, N.W., Washington, DC 20036.
MCB Chemical Reference Manual, MCB Chemical Company, 2909 Highland Avenue, Norwood, OH 45212.
Merck Index, Merck and Company, Inc., Rahway, NJ. (Cost)
Radiation Protection in Educational Institutions, National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Washington, DC 20014. (Cost)
Safety First in Science Teaching, Division of Science, North Carolina Department of Public Instruction, Raleigh, NC 27611.
Safety in Academic Chemistry Laboratories, American Chemical Society, 1155 16th Street, N.W. Washington, DC 20036
Safety in the Chemical Laboratory, Norman V. Steere, Ed. reprints in threes volumes.
Volume 2--February 1967 through January 1970. 1971 Paperback, 132 pages, $17.00
Volume 3 February 1970 through January 1974. 1974 Paperback 157 pages, $17.00
Volume 4 January 1974 through 1980 Edited by M.M. Renfrew, 1981 Paperback, 150 pages, $20.00 Cost includes shipping. Send prepaid orders to Subscription and Book Order Department, Journal of Chemical Education, 1991 Northampton Street, Easton, PA 18042.
Safety in the Secondary Science Classroom, National Science Teachers Association, 1742 Connecticut Avenue, N.W. Washington, DC 20009. (Cost)
Sigma Catalog, Sigma Chemical Company, P.O. Box 14508, St. Louis, MO 63178.
Additional References
Campbell, Monica and Glenn, William, *Profit from Pollution Prevention*, Pollution Probe Foundation, Toronto, Ontario, Canada 1982.

Dictionary of Terms Used in the Safety Profession. American Society of Safety Engineers, 850 Busse Highway, Park Ridge, IL 60068.
Fawcett, H.H., "Exposures of Personnel to Laboratory Hazards", *American Industrial Hygiene Association Journal*, 33:559-564, 1973.
"Fire Protection for Laboratories Using Chemicals", National Fire Protection Association, Quincy, MA.
"Fire Protection Guide on Hazardous Materials", 7th Ed., National Fire Protection Association, Quincy, MA.
Gass, James R., "Preservation of Evidence After a Laboratory Incident Causing Injuries", *Journal of Chemical Education*, Vol 50, No 10, Oct 1973.
Greene, M.E., and True, A, "Safety in Working With Chemicals", MacMillan Publishing Co., New York, 1978.
Guide for Safety in the Chemical Laboratory, 2nd Edition, Van Nostrand Reinhold Co., Litton Educational Publishing, Inc., New York, 1972.
Guide to Precautionary Labeling of Hazardous Chemicals, 6th Edition, Manufacturing Chemists Association, Inc., Washington, DC, 1961.
Handbooks on Radiation and Radioactivity, National Bureau of Standards, Washington, DC, (For complete list, write the National Bureau of Standards.
"Hazardous Chemical Reactions", NFPA Manual 491-M, National Fire Protection Association, Quincy, MA. ($32.25)
Hedberg, D.D., and Russell, E., "Lab Safety Questionnaire", *Journal of Chemical Education*, 55, 148, 1978.
Huisingh, Donald (ed.), *Making Pollution Prevention: Ecology with Economy as Policy*, Pergammon Press, Inc., Elmsford, NY, 1983.
Jones, W.H., "Guard Against Hazards in Chemical Laboratory", *Health and Safety*: 32-35, Nov.-Dec., 1975.
"Laboratory Safety Handbook", Mallinckrodt Chemical Works, St. Louis, MO., 1969.
Matheson, Coleman and Bell, *Safety in Handling Hazardous Chemicals*, 2909 Highland Avenue, Norwood, OH.
Morton, Thomas H., "Zero Effluent Laboratory: An Educational Experiment, A Chemistry Professor's Viewpoint" ACS Forum on Hazardous Waste Management at Academic Institutions: Western and Midwestern Regional Meetings, American Chemical Society, Washington, DC, 1983.
National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, National Academy Press, 2101 Constitution Ave, N.W. Washington, DC, 1983. (Cost)
National Research Council, *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, Washington, DC, 1983. (Cost)
National Safety Council, Chemical Information Sheets (Mini-data sheets) and Index to Data Sheets (Includes Chemical Data Sheets), 444 N. Michigan Avenue, Chicago, IL.
Phifer, Lyle H. and Mathews, Clayton, "Small Quantity Approach to Laboratory Economy and Safety" *American Laboratory*, August 1978.
Phifer, Russell W., "How to Handle the Special Problems of Laboratory Waste Management" *AIPE Journal*, January/February 1984, p 32-34.
Pine, Stanley H., "Chemical Management: A Method for Waste Reduction" *The Journal of*

Chemical Education, February 1984, pp. A45-A46.
Renfrew, M.M., "Highlighting Safety Practices to Students", *Journal of Chemical Education*, 55, 145, 1978.
"Safe Handling of Compressed Gases in the Laboratory and Plant", The Matheson Company, East Rutherford, NJ.
"Science Safety Handbook", Massachusetts Association of Science Teachers, P.O. Box 87, Worchester, MA, 1977.
Scott, R.B., Jr., "Control of Hazards in Laboratories", *Journal of Chemical Education*, 55, A 129, 1978; 55, A 193, 1978.

Chapter 13

Biology Laboratory Safety

The National Association of Biology Teachers (NABT) adopted the following statement on safety in 1994:

Safety. Approved guidelines for the safe use, maintenance and storage of laboratory materials must be followed. This includes classroom instruction on safety and emergency procedures. *NABT Guidelines for the Use of Live Animals, Working with DNA & Bacteria in Precollege Science Classrooms* (or safety guidelines from organizations such as NIH, the American Chemical Society, Flinn Scientific, etc.) and appropriate safety procedures for using plants and microorganisms should be followed. Each laboratory room must be equipped with safety goggles and laboratory aprons for all students, a firstaid kit, a fire blanket, and an all-purpose fire extinguisher. A safety shower and eyewash station should be available within a 20-second walk. Safety goggles, if used by different students, must be disinfected with an alcohol swab wipe before being assigned to another user. The state Department of Education guidelines for safety procedures should be rigorously followed.

For further information about this and other publications contact NABT. (1) Note: It is recommended that laboratory classrooms in Illinois be equipped with sterilization cabinets with

U-V light for sterilizing safety goggles.

13.0 The Biology Classroom

Chapters 1-12 contain comprehensive information about the science laboratory. While the biology classroom is unique in having biological specimens, it is in many respects similar to other science labs. The reader should consult the previous chapters for general information. Use Chapter 13 for information specific to the needs of the biology classroom.

13.1 Microbiology

This section pertains to viruses and bacteria, and other microscopic organisms.

13.1.1 Obtaining Materials

A. Sources - Because of the hazards involved in handling, identification and proliferation, it is strongly recommended that specimens be obtained from reliable supply companies or other sources that can validate species or strains. A comprehensive list of sources is available in the NSTA publication, *NSTA Science Education Suppliers 1996*. (2) Other sources may include local research facilities, e.g., universities or hospitals. The American Type Culture Collection (3), a not-for-profit organization, maintains an extensive collection of microbiological specimens which are available to teachers. This source is especially useful for obtaining materials not available through other suppliers. Materials should be requested for shipment when needed and not stored for long periods of time to minimize deterioration and/or spreading in the environment.

B. Pathogens - All microorganisms should be handled as though they are pathogens. This emphasizes proper lab technique. Known pathogens should *never* be used. Most supply houses will indicate which organisms are pathogens in their catalogs.

13.1.2 Use

A. Material requirements

1. Laboratory - To deal with microorganisms one must have available for use: proper sterilization equipment, sterile transfer equipment, workspace and equipment to prepare

media, proper storage facilities including refrigeration and incubation equipment, supplies for clean up and disinfecting work areas. Special trash containers should be available for broken glass only.
2. Personal safety - For personal safety common sense dictates that the laboratory be as immaculate as possible. No eating or drinking should be allowed. Air currents should be minimized to avoid contamination. Latex gloves, goggles, and aprons should be used as the teacher deems necessary. Students should be instructed in the use of safety equipment in the classroom.
B. Aseptic techniques
1. Area preparation - All work areas should be washed down with disinfectant and allowed to dry before use. This minimizes dust and the chance for accidental contamination.
2. Autoclaving - An autoclave should be available for media preparation, sterilization of glassware and equipment, and for destroying organisms after use. A pressure cooker may be used as a substitute, but it requires greater attention because of the hazards involved in a nonautomatic system. Note: most plastic containers and equipment such as Petri dishes are *not* autoclavable.
3. Handling - Any time a microorganism is handled, aseptic techniques should be followed. Under no circumstances should mouth pipetting be allowed.
a. Disposable equipment - Because of the nature of viruses, only sterile disposable equipment should be used. Although the cost may be higher, it is also recommended for use with other microorganisms.
b. Sterilizable equipment - Glassware should be cleaned, then wrapped in newspaper before being placed in the autoclave. Autoclave tape should be used where possible to indicate that the equipment has been properly sterilized. The equipment should remain wrapped until use. Transfer equipment such as wire needles and loops should be flamed in an open flame and then allowed to cool before use. This equipment *must* be flamed again after use before reuse or storage.

13.1.3 Storage

Different experimental materials require special storage techniques. Storage information is provided by suppliers and should be followed. Refrigeration facilities must be available. In order to insure viability and to minimize contamination, do not store microorganisms for long periods of time. Use as soon as possible and destroy after use.

13.1.4 Disposal

It is extremely important to dispose of microorganisms properly. They should be destroyed to avoid the possibility of contaminating the environment. Even non-pathogens can upset the micro-ecology of an area.
A. Dry Heat Sterilization - Equipment can be placed in an oven at 160-190 degrees Celsius (320-374 degrees F) for 30 minutes.
B. Steam Sterilization - Equipment should be autoclaved at 121°C at 15 lbs. pressure for 20 minutes.
C. Chemical Sterilization - Commerically available disinfectants or bleach may be used to sterilize working areas and for destroying cultures grown in plastic containers such as disposable Petri plates.

13.2 Botany

13.2.1 Recommendation for Use

Plants should be used whenever possible as experimental organisms.

13.2.2 Care

Plant care requirements are usually far less demanding than animal care. Facilities necessary include proper lighting, adequate heat, and water and nutrients. Containers should be clean before use. Clay pots should be scrubbed and then soaked in a 10% bleach solution before reuse. This is especially true when experiments are being conducted to avoid contamination factors. Commercial potting mixtures are recommended over garden soil because they are sterile.

13.2.3 Cautions

A. Poisonous plants - Certain plants and plant parts as well as fungi contain chemicals which are harmful. Some are poisonous upon skin contact, e.g., poison oak or poison ivy; latex gloves will help to avoid skin contact. Other plants are poisonous when ingested, e.g., foxglove. No plant should be ingested in the biology laboratory. Students should be made aware of poisonous plants and be able to identify any such plants on sight. Contact the local poison control center through the County Health Department or local hospital for specific information regarding procedures to follow.

B. Allergic reactions - Teachers should be aware that some students may be allergic to pollen, spores or other airborne plant exudates. Precautions to prevent dispersal should be taken to minimize exposure.

C. Other cautions - Many succulents and other plants have thorns or needles. These may be very annoying and even dangerous if contact is made with the skin or eyes. Students should be made aware of the dangers of handling such plants.

13.2.4 Disposal

A. Exotic plants - These plants should never be released into the environment where they may compete with local plants. They can severely upset the balance in nature. For example, the kudzu plant and purple loosestrife have become pests of major proportions.

B. Native plants - These plants normally should not present a problem for the local environment and should be disposed of in a manner consistent with school policy and local ordinances.

13.3 Zoology

13.3.1 Human Considerations

A. Humans as experimental organisms - Non-invasive, nonstressful laboratory activities using students as experimental organisms are encouraged. These include physiological measurements such as, pulse, heart rate, breathing rate, hearing, sight, etc.

B. Human body fluids - In recent years, the public has become very concerned about the use of bodily fluids in the classroom. Formerly blood typing and clotting, urinalysis, etc. were done as classroom activities. Most teachers feel that there is too much risk doing these activities. Artificial blood and fluids are available from suppliers. However, students should be encouraged to find out their blood types from their doctors so that this information can be used as data. It is also important that children know their blood types in case of emergency. For information concerning *accidental exposure and cleanup* see Chapter 6.5.

13.3.2 The use of Animals in Biology Education - NABT Statement

The National Association of Biology Teachers (NABT) believes that the study of organisms, including nonhuman animals, is essential to the understanding of life on Earth. NABT recommends the prudent and responsible use of animals in the life science classroom. NABT believes that biology teachers should foster a respect for life. Biology teachers also should teach about the interrelationship and interdependency of all things. Classroom experiences that involve nonhuman animals range from observation to dissection. NABT supports these experiences so long as they are conducted within the long established guidelines of proper care and use of animals, as developed by the scientific and educational community.

As with any instructional activity, the use of nonhuman animals in the biology classroom must have sound educational objectives. Any use of animals, whether for observation or dissection, must convey substantive knowledge of biology. NABT believes that biology teachers are in the best position to make this determination for their students. NABT acknowledges that no alternative can substitute for the actual experience of dissection or other use of animals and urges teachers to be aware of the limitations of alternatives. When the teacher determines that the most effective means to meet the objectives of the class do not require dissection, NABT accepts the use of alternatives to dissection including models and various forms of multimedia. The Association encourages teachers to be sensitive to substantive student objections to dissection and to consider providing appropriate lessons for those students where necessary. To implement this policy, NABT endorses and adopts the Principles and Guidelines for the Use of Animals in Precollege Education of the Institute of Laboratory Animals Resources (National Research Council). Copies of this publication may be obtained from NABT or the ILAR.

13.3.3 Living Material (nonhuman)

A. Obtaining animals - Under no circumstances should vertebrate animals be taken from the environment. The teacher should use good judgment in obtaining any invertebrate animals from the environment. We recommend that all animals be obtained from authorized suppliers.

B. Use

1. Vertebrates - Vertebrate animals should be used only for observational activities and to teach students proper care and handling. No invasive procedures should be done on living vertebrate animals. Such activity is prohibited by the Illinois School Code 105 ILCS 5/ 27-14 which follows:

Experiments upon Animals. No experiment upon any living animal for the purpose of demonstration in any study shall be made in any public school. No animal provided by, or killed in the presence of any pupil of a public school shall be used for dissection in such school, and in no case shall dogs or cats be killed for any purposes. Dissection of dead animals, or parts thereof, shall be confined to the classroom and shall not be practiced in the presence of any pupil not engaged in the study to be illustrated thereby. Laivs 1961, p.31, and 27-14, eff. July 1, 1961.

2. Invertebrates - Invertebrate animals are often used for observational and genetic experiments. For example, the fruit fly, *Drosophila sp.* is used in genetics. Care should be taken to anesthetize organisms properly. If ether is used, it must be stored in an explosion-proof refrigerator. Any anesthetic should be used in a properly ventilated room according to directions given by the supplier. Other methods, such as icing, should be considered as viable alternatives where possible. It is recommended that teachers obtain a manual available from local biological suppliers. These manuals are complete guides for maintaining and studying this organism in the classroom.

C. Care - Living organisms have special needs. Requirements for care accompany shipments from reliable sources. Special manuals are available for many organisms. We encourage the purchase and use of these manuals. All animals should be handled gently. They should be given adequate nourishment, water, and ventilation. Cages or other housing should be cleaned regularly. Leather gloves should be worn when handling animals which have the ability to bite or claw.

D. Disposal - When the use of the organism is complete, proper disposal is required. Do not release animals into the environment. They may become feral and compete with local fauna. For example, the clawed frog, *Xenopus*, became a major problem on the west coast where it was released from a lab into the environment. Animals should be euthanized humanely for disposal.

13.3.4 Preserved Materials

A. Obtaining

1. Sources - Preserved animals should be ordered from sources which obtain organisms in a humane manner. The source should guarantee to supply properly fixed and preserved specimens. Major biological supply houses (2) make this guarantee.
2. Quantities - Teachers should assess their needs carefully. Only enough material should be ordered to supply one school year. Specimens should not be stored from year to year since deterioration may occur.
3. Preservatives - Specimens are first fixed and then preserved. According to Flinn Scientific, "Fixation is the process which uses a dilute solution of formaldehyde to stabilize proteins and destroy microorganisms. When an animal has been properly fixed, autolysis and microbial breakdown should not occur. Following fixation, various procedures are used by suppliers to transfer specimens into formaldehyde-free preservatives."(5) Formalin is an aqueous solution of formaldehyde. Nonformaldehyde preservatives are generally considered safer for student use. Preserved animals are available that are totally formaldehyde free. These tend to be more expensive. Check with your supplier.

Eye protection should be used during dissection activities. Students should be encouraged to wash their hands after handling specimens. Latex gloves should be available for student use. Food should not be allowed in the laboratory.

B. Use

1. Dissection Equipment - All equipment must be clean. Scalpels and scissors must be sharp for effective use. Students should be taught to use dissection equipment properly. Dissecting is an activity that requires precise motor skills that must be developed. Students should understand the reason for dissecting. It is an activity that should be treated very seriously. Proper attitudes toward dissection will increase the value of the activity and encourage sensitivity of students toward living things.
2. Dissection Clean-up - Students should be given time to clean tools, pans, and dissecting stations before the end of the lab session. They must also wash their hands thoroughly. If the dissection is to be continued at a later time, specimens should be placed in plastic bags to prevent desication and to aid in identification. When finished with the dissection, all tissues should be disposed of in a common container made available for this purpose.

C. Storage - Before use, specimens should be kept in their original containers and placed in an area not available to students.

D. Disposal - After checking with local authorities excess preservative fluids should be flushed down the sink with plenty of water. Unused specimens should be placed in a container for disposal in accordance with school policy.

13.4 Biotechnology

Many classrooms have introduced hands-on science labs dealing with the topics of molecular biology and biotechnology. Work with DNA is at the core of many of these activities. Spooling, enzymatic digestion, and electrophoresis of this molecule to study its chemical and physical properties, as well as manipulating bacterial cells to introduce new genetic properties, have become commonplace. The Advanced Placement Biology Curriculum Outline (6) recommends lab experiences which include the electrophoresis of DNA and bacterial transformation experiments. Safety, as always, is a crucial part in the performance of these labs. Guidelines for the safe handling of these materials have by now been well established, patterned after practices followed in research laboratories. These include procedures for handling chemicals and microorganisms, maintaining a safe workplace, and the disposal of used materials and cells. The guidelines outlined in 13.4.1 summarize procedures which should be followed when working with biotechnology labs to ensure that the activities will be performed safely.

13.4.1 Handling Microorganisms and DNA in the Laboratory

The key to handling any microorganism or DNA molecule in the laboratory is to follow *Standard Microbiological Practice* as described in the manual, *Biosafety in Microbial and Biomedical Laboratories*. (7)

1. Handle all microorganisms and DNA carefully; treat them as if they could cause infections.
2. Restrict access to the laboratory during lab periods when microorganisms or DNA are being experimented with (e.g., keep the door closed).
3. Do not eat, drink, or apply cosmetics in the laboratory. Keep fingers and writing instruments away from your face and mouth.
4. Wash your hands with soap and water before and after handling microorganisms and before leaving the laboratory regardless of what materials were used. If you have cuts on your hands or arms, wear latex (or rubber) gloves for protection when handling living materials (e.g., microorganisms).
6. Do not use mouth pipetting for transferring any material; use only mechanical devices.
7. Perform procedures carefully to minimize the formation of aerosols. For example, place pipette tips close to liquid surfaces or near tile bottom of empty receiving containers and discharge fluids down the inner wall of the receiving container. Do not force the last drop from a pipette. Keep pipette tips away from the face to avoid inhaling any aerosol that may be formed.
8. Decontaminate work surfaces before and after the laboratory period and any surface after a spill of living materials. Decontaminating solutions should be readily available and contained in lab squeeze bottles.
9. Dispose of all used solid and liquid materials in specially marked containers. These containers should be easily accessed by students, preferably located at each lab station.
10. Decontaminate all liquid and solid wastes that have been in contact with experimental microorganisms, and kill all experimental microorganisms before disposal.
11. The wearing of protective goggles while working in the laboratory is recommended.

13.4.2 Biogenetic Experimentation

A. Organisms - According to NABT's *Working with DNA and Bacteria in Precollege Science Classrooms* (8), *Escherichia coli (E. coli)* is the standard experimental bacterium. It is a normal resident of the animal (including human) digestive tract. Many strains of *E. coli* are known, a few of which can cause significant disease in humans. The laboratory strains commercially available usually do not cause disease. They are designed in such a way that they cannot normally survive outside of the prescribed conditions of the laboratory. However, all of these could cause infection if introduced directly into an open wound or the eye. It is important therefore to adhere strictly to good microbiological practices.

Agrobacterium tumefaciens does not cause disease in humans. However, the same precautions for safe handling of microorganisms should be followed.

B. Disinfecting and Decontamination - Before carrying out any experiment involving microorganisms, wipe down the laboratory workspace with disinfectant solution. The procedure should be repeated at the end of the lab period as well. Clean up any spills involving microorganisms immediately by disinfecting the spill area thoroughly. Keep disinfectants readily available at work stations in laboratory squeeze bottles. Disinfectant aqueous solutions may be made of 2% commercial disinfectant, 10% bleach, 70% ethanol, and rubbing alcohol. Liquids or solids that have come in contact with living microorganisms, or experimental microorganisms themselves may be decontaminated by steam sterilization. A steam autoclave or pressure cooker set at 121°C., and 15 pounds of pressure, for 20 minutes, will be sufficient to decontaminate or kill living materials. Alternatively, flooding contaminated equipment (e.g., Petri plates) or living materials with 10% bleach solution for one hour will produce the desired effect; pour off the disinfectant solution, disposing of it down the drain. Only glassware that is to be used again need be rinsed with running water. Materials that have come in contact only with DNA or restriction enzymes need not be disinfected. These include pipette tips or other delivery devices, Eppendorf tubes, and electrophoresis gels.

C. National Institute of Health Guidelines - The NIH has developed a set of guidelines for conducting research using recombinant molecules and organisms. Over 20 years of experience with this kind of research has led to the conclusion that most experiments are safe to conduct under appropriate conditions and with responsible handling. As a result, many types of experiments have been declared exempt from the guidelines. The usual experiments done in precollege teaching laboratories are of this type. If students wish to pursue research beyond these labs, teachers should make sure that only exempt molecules and microorganisms are used. Refer to *NIH Guidelines for Research Involving Recombinant Molecules* (9) or contact a local university or research laboratory for advice.

D. Staining DNA - Ethidium bromide and methylene blue are the common stains for viewing DNA after electrophoresis. Ethidium bromide is universally used in research labs because it is more sensitive (i.e., can detect minute quantities of DNA) and it is quicker to use. It is, however, a mutagen and a suspected carcinogen. For these reasons, the use of ethidium bromide in the precollege classrooms of Illinois is prohibited. Methylene blue (or a commercial derivative) will also stain DNA; however, it is not as sensitive. Methylene blue is moderately toxic and will stain skin. Latex gloves should be worn when handling this stain. Check local regulations for safe disposal of methylene blue. Do not pour it down the drain without checking with local authorities first.

E. Conducting Gel Electrophoresis - Gels are run at high enough electrical voltages, 75-140 volts, to cause severe jolts. Gel boxes should have built-in safety features that interrupt current flow when the cover is removed. Home-built boxes should incorporate this feature. Students should be warned against sticking fingers or other electricity-conducting materials (e.g. paper clips, pencils, etc.) into the electrophoresis buffer solution while the gel box is in operation.

13.5 Radiation (see chapter 10)

13.6 Outdoor Education (see chapter 15)

13.7 References

1. *NABT Guidelines for the Use of Live Animals, Working with DNA & Bacteria in Precollege Science Classrooms*. National Association of Biology Teachers, 11250 Roger Bacon Drive, Reston, VA 22090; (800)406-0775.

2. *NSTA Science Education Suppliers 1996*. National Science Teachers Association, 1840 Wilson Blvd., Arlington, VA 22201-3000; (703)243-7100.

3. American Type Culture Collection, 2301 Parklawn Drive, Rockville, MD 20852; (301)881-2600.

4. *Principals and Guidelines for the Use of Animals in Precollege Education*. Institute of Laboratory Animals Resources, 2101 Constitution Avenue, NW, Washington DC 20418; (202)334-2590.

5. *Flinn Biological Catalog/Reference Manual, 1996*. Flinn Scientific, Inc., 131 Flinn St., P.O. Box 219, Batavia, IL 60510; (800)452-1261.

6. *Advanced Placement Biology Curriculum Outline*. College Entrance Examination Board
and Educational Testing Service, P.O. Box 6670 Princeton, NJ 08541-6670.

7. *Biosafety in Microbiological and Biomedical Laboratories*. Center for Disease Control and the National Institutes of Health, GPO, Washington, DC 20402.

8. *Working with DNA and Bacteria in Precollege Science Classrooms*. Toby M. Horn, 1993, National Association of Biology Teachers, 11250 Roger Bacon Drive, Reston, VA 22090; (800)406-0775.

9. *NIH Guidelines for Research Involving Recombinant Molecules*. National Institute of Health, GPO, Washington, DC 20402.

Chapter 12

Model Chemical Hygiene Plan

In 1992 Illinois adopted the federal "Occupational Exposures to Hazardous Chemicals in Laboratories" legislation (29 CFR 1910.1450). This legislation requires all employers to develop a Chemical Hygiene Plan which details how each employee will be protected from overexposure to hazardous chemicals and to describe specific work practices and procedures in the laboratory to minimize employee risk. Students are not considered employees under this law, but prudence dictates that they should be expected to comply with all practices and procedures in this plan.

I. Responsibilities

Specific to this Chemical Hygiene Plan for ____________ High School, employees, administrators, and students each have responsibilities to conform to this standard. The senior administrative officer is "ultimately responsible for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene. (29 CFR 1910.1450 (Appendix A)(B)(1)."

A. Administration's Responsibilities

1. Appoint a Chemical Hygiene Officer
2. Implement a Chemical Hygiene Plan conforming to the OSHA Lab Standard (29 CFR 1910.1450)
3. Train employees with provision of the Chemical hygiene plan including:

a) the location and availability of the OSHA Lab Standard, school Chemical Hygiene Plan, material safety data sheets (MSDSs) and other safety information. These references must include Permissible Exposure Limits (PELs) or Threshold Limit Values (TLVs), and signs and symptoms associated with exposure;
b) the physical and health hazards of the chemicals with which the employee works;
c) work practices, personal protective equipment, and emergency procedures to be used to ensure protection from overexposure to the hazardous chemicals used

4. Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment
5. Maintain a record of all chemical exposures and provide employee access to these records as well as any medical records**.**

B. Teacher's Responsibilities

1. Know the properties and safety hazards associated with each laboratory activity before the students carry our the procedure.
2. Insure that all safety equipment is present in the laboratory and is in good working condition.
3. Provide eye protection and other necessary personal protective equipment for students.
4. Ensure that all chemical are properly labeled with their contents and hazards.
5. Make sure that all safety rules are obeyed.
6. Promptly clean-up or direct the clean-up of spilled chemicals.
7. Dispose of chemical wastes properly.
8. Comply with the procedures in the school Chemical Hygiene Plan.
9. Report any accidents or unsafe conditions in writing to your department chairperson, principle, or other appropriate administrator.

10. Request information and training when unsure how to handle a hazardous chemical or situation.

C. Student Responsibilities

1. Understand the experimental procedure before starting to work in the laboratory.
2. Be familiar with the properties and hazard of the chemicals you are working with.
3. Obey all safety rules and regulations.
4. Clean you work area immediately after use. Obey good housekeeping practices.

II. Basic Rules and Procedures

"The Chemical Hygiene Plan shall include...standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals." (29 CFR 1910.1450(e)(3)(i)).

A. General Rules

1. **Know the safety equipment**. Know the location of eye wash fountains, safety showers, fire blankets, fire extinguishers, first aid kits, and emergency exits. Know how to respond in case of an emergency. Know how to use the safety equipment.
2. **Know the hazards of the materials being used.** Read labels carefully to make sure you are using the right chemical. Know how to interpret data from a MSDS. Remember that hot and cold glassware look the same, so allow ample time for cooling.
3. **Never engage in horseplay, games, or pranks in the laboratory**. Remember that the laboratory is a place for serious work. Careless behavior can endanger yourself and others and will not be tolerated.
4. **Demonstrate safe behavior**. Obey all safety instructions given by your instructor or found in your experimental procedure. Clean up spills immediately if you know how. If you are uncertain how to clean up a spill, or for large spills, notify your instructor immediately. Before leaving the laboratory, return equipment and chemicals to their proper place. Clean up your work area.
5. **Dispose of all waste materials according to your teacher's instructions**.
6. **Report any accidents or unsafe conditions to your teacher immediately**.

B. Prior Approval

1. **Carry out only the experiments assigned by your teacher**. Never perform unauthorized experiments.
2. **Never remove chemicals from the laboratory**.
3. **Never work in the laboratory unless authorized to do so by your teacher**. Never work alone in the laboratory. In case of an accident, you may need another person to prevent injury or even save your life.

III. Control Measures

"The Chemical Hygiene Plan shall include... criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices...." (29 CFR 1910.1450(e)(3)(ii)).

A. Personal Hygiene

Practicing good personal hygiene will minimize exposure to hazardous chemicals. The following procedures should be followed:

1. **Do not eat, drink, or apply cosmetics in the laboratory**. By engaging in these activities you can accidentally ingest harmful chemicals.
2. **Do not taste any chemical**.

3. **Do not smell chemicals directly.** Smell a chemical only if your teacher specifically tells you to do so. Use your hand to fan the vapor to your nose.
4. **Do not pipet solutions by mouth**. Use a rubber suction bulb or other device to fill a pipet.
5. **Wash your hands with soap and water before leaving the laboratory**. This rule applies even if you have been wearing gloves.

B. Protective Clothing and Equipment

Clothing worn in the laboratory should offer protection from splashes and spills, should be easily removable in case of an accident, and should be fire resistant. The following rules should be followed:

1. **Protect your eyes**. Appropriate eye protection must be **worn at all times** in the laboratory. Goggles provide maximum protection from splashes. Contact lenses should not normally be worn unless approved by your teacher. Unventilated goggles are essential if contact lenses are to be worn.
2. **Wear appropriate protective clothing**. Chemicals may be burn or irritate the skin. Some chemicals are readily absorbed through the skin and enter your body. Your clothing should cover your legs to the knees. Shorts are not appropriate for the laboratory. Laboratory coats or aprons can protect good clothing. Loose clothing should not be worn because it may dip into chemicals or fall into a flame and catch fire.
3. **Wear shoes that cover your feet**. Sandals and open-toed shoes offer no protection to your feet from broken glass that is frequently found in science laboratories. Also, shoes protect your feet from chemical spills.
4. **Tie back loose hair**. Dangling hair may fall into a Bunsen burner and catch on fire or may fall into a chemical solution.
5. **Carefully inspect all protective equipment before using**. Do not use any defective personal protective equipment. Report any defective equipment.

C. Housekeeping Rules:

In the laboratory and elsewhere, keeping things clean and neat usually leads to a safer environment.

1. Never block access to emergency equipment — showers, eye wash, fire extinguishers, fire blankets — and emergency exits.
2. All chemical containers must be labeled with at least the identity of the contents and hazards associated with the chemical. Label all reagents with the name of the preparer and date of preparation.
3. Wastes should be segregated into appropriate containers and properly labeled.
4. Do not use chipped, cracked, or broken glassware. Place broken glassware and disposable glassware into appropriately labeled containers.
5. Never throw solid materials into sinks; use the appropriate waste containers.
6. Do not put pipets or spatulas into reagent bottles. Do not return unused chemicals or solutions to their original bottles. Contamination can ruin current and future experiments and result in a larger amount of waste for disposal. To weigh solids, transfer the desired amount to glazed weighing paper or the appropriate glassware. Do not weight solids directly on the pans of a balance.
7. Clean up any spills on the floor or bench immediately. Ask your instructor if you are not sure how to treat the spill.

8. Clean the area when your work is finished. Check to make sure all gas and water outlets are completely shut off. Put away all items used in the experiment in their proper place.

D. Hazardous Material Handling and Storage

1. All chemicals in the stockroom should be stored according to chemical compatibility.
2. Use appropriate shelving or cabinets. If metal clips are used to hold shelves, they should be inspected for corrosion and replaced as necessary.
3. Store flammable liquids in approved fire cabinets.
4. Make sure shelves holding containers are secure. Attach anti-roll lips on shelves to prevent chemicals from falling.
5. When opening newly received chemicals, immediately read the warning label to be aware of any special storage precautions like refrigeration or inert atmosphere storage.
6. No chemicals are to be stored in aisles or stairwells, on desks or laboratory benches, on floors or in hallways.
7. Maintain a complete inventory in the room where chemicals are stored.
8. Mark the acquisition dates on all peroxide forming chemicals, and test them for peroxides or dispose of them after six months.
9. Have spill cleanup supplies (absorbents, neutralizers) in any room used for chemical storage or use.
10. Protect the school environment by restricting emissions from stored chemicals. The air supply from the stockroom should be ducted to the outside.
11. Use refrigerators of explosion-proof or explosion safe design only! Standard refrigerators that have not been converted should never be used to store flammable chemicals.
12. Chemicals should be dated upon receipt, dated to be disposed where appropriate, and dated when opened (e.g., peroxides, anhydrous ethers, sodium nitrites).
13. Chemical containers should be periodically checked for rust, corrosion, and leakage.
14. Chemical labels should state name for chemical, be firmly attached to the container, list hazards, and name responsible party.
15. Chemical labels should be readable and free from chemical encrustation.
16. Maintain a clear access to and from the storage areas.
17. Where possible, storage areas should be planned with two separate exits.

D. Inspections

1. Eyewash fountains should be flushed for three minutes each week.
2. Safety showers should be tested at least annually
3. Fume hoods should be monitored at least annually to make sure their flow is adequate (60-120 cfm).
4. Fire extinguishers should be checked to make sure they are of the correct type (ABC) and are at recommended pressure.
5. Safety goggles and aprons should be inspected prior to each use.
6. Safety inspections should be made every three months to monitor housekeeping and to make sure safety equipment is working. The record of these inspections must be recorded.

IV. Medical Program

“The Chemical Hygiene Plan shall include... provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section." (29 CFR 1910.1450(e)(3)(vi)).

A. Exposure

When employees or supervisors suspect that an employee has been exposed to a hazardous chemical to a degree and in a manner that might cause harm to the victim, the victim is entitled to a medical consultation and examination without cost and loss of pay to the employee. Medical records should be retained according to state and federal laws. The events and circumstances that might result in overexposure to a chemical are:

1. a hazardous chemical leaked, was spilled, or otherwise released in an uncontrolled manner;
2. a hazardous chemical was spilled on the skin or splashed in the eye;
3. a person displays symptoms that might indicated overexposure to a hazardous chemical such as rash, headache, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgment, and others.

B. Exposure Assessment

All complaints about chemical exposure are to be documented on the Accident Report Form along with any action taken. If no further action is taken, the reason for that decision should be included. If it is decided to investigate the incident the following steps should be undertaken after the victim is treated.

1. Interview the victim to determine the symptoms and circumstances of the possible exposure.
2. List the chemical under suspicion and other chemicals being used by the victim and in the laboratory.
3. List the symptoms exhibited or claimed by the victim and compare these symptoms to those stated in the Material Safety Data Sheet.
4. Were personal protective equipment and engineering controls, such as fume hoods, in proper working order and were they being used properly?
5. Monitor or sample the air and document the results.
6. Determine if the present control measures and safety procedures are adequate.

V. Signs and Labels

The following signs and labels should be posted prominently in the laboratory:

1. emergency telephone numbers of emergency personnel, emergency facilities, administration, and the teacher;
2. identity labels showing the contents of containers (including waste receptacles) and associated hazards;
3. location of exits, safety showers, eyewash station, fire extinguisher, fire blanket, and other safety equipment;
4. label any laboratory refrigerator "NO FOOD";
5. warnings at areas or equipment where special or unusual hazards exist.

VI. Spills and Accidents

1. Each school should have an emergency plan in place. Each student, teacher and staff member should know immediately what to do and where to go in case of any emergency.
2. Take immediate notice of persons who may have come into contact with the spilled chemical. Address their needs promptly.
3. Evacuate the spill area. Until you are certain that the spill is not hazardous to students in the general area, limit the number of people who might be exposed.

4. Protect yourself. Never clean up a spill without proper protective clothing.
5. Identify the chemical that is spilled, isolate it, and contain it.
6. Clean up and dispose of the chemical in a safe, legal, and responsible way.
7. Clean up yourself disposing of gloves you used in the cleanup.

VII. Waste Disposal

“Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal or waste laboratory chemicals.” (29 CFR 1910.1450(Appendix A)(11)(a)).

1. Waste should be collected for disposal at frequent intervals.
2. Indiscriminate disposal by pouring waste down the drain or adding them to the general trash is unacceptable.

[Specify how your school waste is collected, segregated, stored, transported and disposal method(s) used..]

VIII. Training

Employers should provide employees with information and training to ensure they are aware of the hazards of chemicals that are present in their work area. This training must include:

1. the location and availability of the OSHA Lab Standard, school Chemical Hygiene, Plan, chemical safety reference materials, including Material Safety Data Sheets, and the PELs for OSHA regulated substances;
2. the applicable details of the OSHA lab standard and the Chemical Hygiene Plan;
3. signs and symptoms associated with exposure to hazardous chemicals with which they may work;
4. methods and observations that may be used to detect the presence or release of a hazardous chemical (visible appearance, odor, monitoring equipment);
5. work practices, personal protective equipment, and emergency procedures to protect workers from overexposure to hazardous chemicals.

IX. Records

Sample Signoff Sheet for the Chemical Hygiene Plan

After reading the ____________ School Chemical Hygiene Plan, please complete and return this form to your supervisor or departmental office.

Your supervisor will provide additional information and training as appropriate.

I acknowledge that I have read, understood, and have received a copy of the _______ School Chemical Hygiene Plan. Also, I have had the opportunity to ask and receive answers to questions I had concerning this document.

Signature ________________________ Date ______________

Name (Please print) ________________________

Social Security Number ____________________

Supervisor ____________________

Job Classification ________________

Chapter 14
Elementary Science Safety Standards
Introduction

The information presented here is correct to the best of our knowledge. Suggestions provided should be considered as the minimum applicable safeguards and should be used in conjunction with appropriate standards, regulations, state requirements, and federal codes that may prevail. The intent is to provide a guide to preventive measures which will avoid unsafe practices and also prepare teachers for any possible accidents. Of course, good common sense on the part of the teacher will avoid most situations where harm might come to students. To prevent injuries, teachers must attempt to foresee problems and address them immediately. Teachers must provide adequate supervision applicable for the environment and the degree of hazards anticipated, in addition to ensuring that the environment and equipment items are properly maintained. Teachers can assess the safety situation within their teaching environments (classrooms or field trips) regularly and accurately by developing and using safety checklists regularly. Refer to various safety checklists in this manual (Chemistry Safety, etc.). The assessments should be performed on a regular basis to ensure that safety problems are identified and corrected expeditiously.

14.1 General Safety and Use of Equipment Guidelines (refer to 14.2)

14.1.1 Check your classroom on a regular basis to ensure that all possible safety precautions are being taken. Equipment and materials should be properly stored; hazardous materials should not be left exposed in the classroom.

14.1.2 Be a positive role model for students by always practicing safe behaviors and using necessary protective equipment such as safety goggles.

14.1.3 Before handling equipment and materials, thoroughly familiarize yourself with their possible hazards. Alert students to potential dangers. Safety instructions should be given each time an experiment is begun.

14.1.4 Be extra cautious when dealing with fire and instruct your students to take appropriate precautions.

14.1.5 Be familiar with your school's fire regulations, evacuation procedures, and the location and use of fire fighting equipment.

14.1.6 Know your school's policy and procedure in case of accidents.

14.1.7 Good housekeeping is essential in maintaining safe laboratory conditions.

14.1.8 Sufficient time should be planned for students to perform the experiments, then to clean-up and properly store the equipment and materials after use.

14.1.9 Proper eye protection devices should be worn by all persons engaged in, supervising or observing science activities involving potential hazards to the eye.

14.1.10 At the start of each science activity, instruct students regarding potential hazards and the precautions to be taken.

14.1.11 Be sure that aisles remain clear and uncluttered, and lab or worktables are free of unnecessary and/or potentially hazardous items so that students have adequate room to move about and/or work during any demonstration or activity.

14.1.12 Supervise students at all times during a hands-on activity.

14.1.13 The group size of students working on an experiment should be limited to a number that can safely perform the experiment without causing confusion and accidents. Groups of two are recommended for primary students and groups of three are

recommended for grades three through five.
14.1.14 Students should be instructed never to taste or touch substances in the science classroom without first obtaining specific instructions from the teacher.
14.1.15 All accidents or injuries, no matter how small, should be reported to you immediately.
14.1.16 Students should be instructed that it is unsafe to touch the face, mouth, eyes, and other parts of the body while they are working with plants, animals, microorganisms, or chemical substances and afterwards, until they have washed their hands and cleaned their nails.
14.1.17 Critical safety equipment such as fire blankets, fire extinguishers, eyewashes, and drench showers should be located within thirty steps or fifteen seconds of any location in the science room. These vital equipment items should be checked for proper operation every three to six months.
14.1.18 Be sure that spills are cleaned up immediately. Water on tile floors can make the floors quite slippery.
14.1.19 Keep a whisk broom and dustpan available for sweeping up pieces of broken glass.
14.1.20 Hair and loose clothing (especially sweaters) should be restricted when students are working with open flames. Be careful to pull long hair back so that it does not hang down over the flame.
14.1.21 Never eat or drink during science activities or from laboratory equipment.
14.1.22 Provide for adequate and proper storage of materials and equipment either in the classroom or school storage room. Be certain to store any chemicals or potentially hazardous materials out of the reach of students, preferably in a locked cabinet or storage room.
14.1.23 Be aware of any allergies that students might have to certain foods, plants, chemicals, or other substances used in class.
14.1.24 Be sure you have secured permission from parents before students leave the school grounds, even if the destination is within walking distance.
14.1.25 Especially in the primary grades, be sure students use only nonpointed scissors. If students must walk around carrying scissors, remind them to point the tips of the scissors toward the floor.
14.1.26 Use only water-based, nontoxic glue, paste, and markers in class.
14.1.27 Many hand tools are designed for specific purposes and should be used on a suitable work surface and stored in proper storage facilities.

14.2 Suggested List of Safety Equipment for the Elementary Science Classroom

In accordance with Illinois laws and regulations, all laboratories and science teaching areas should have and use safety equipment appropriate for the type of science activity being conducted. Protective equipment is designed to prevent or minimize injury. It does not prevent accidents from occurring. The following is a list of needed safety items in the science classroom and/or laboratory:
fire extinguishers (see section 14.3.5)
first aid kits

fire blankets
sand buckets
eyewash facilities
safety goggles
laboratory aprons
gloves
tongs

14.3 Specific Safety Equipment Information

Certain safety equipment items are essential when teaching science activities. Teachers should be confident that such items are immediately accessible when needed, that teachers and students can operate them, and that they are appropriate for the student audience being served. Students should also be taught the location and proper operation of all safety equipment items they might need to use. These should include fire extinguishers, fire blankets, eyewashes, safety goggles, and a telephone or intercom, if available. This might necessitate having duplicate safety items in more than one location in the room.

14.3.1 Electrical Equipment

It is recommended that whenever possible hot plates with on/off indicator lights replace open flames. This simple change could eliminate many fire situations from science rooms. You should not have to use extension cords for hot plates, since the room should have sufficient electrical outlets. Extension cords on the floor create tripping hazards unless they are in cord protectors. To prevent students from inadvertently upsetting apparatus, do not allow cords to be draped across desks or other work areas. Electrical outlet caps should be in place when the outlets are not in use. In primary grades, they should be covered at all times to prevent students from putting metal items in the plug holes, which could case electrocution or burns.

14.3.2 Heating Equipment

If open flames are periodically necessary, be certain that emergency fire equipment is functioning properly and is immediately available. If alcohol lamps, sterno cans, or candles are to be used, place them in pie pans filled with damp sand. Should a spill accidentally occur, the pie pan would prevent the liquid from spreading onto clothing, tables, and so on. Since alcohol looks like water, it is essential to keep it off items where it might be treated like water. If you put alcohol in lamps, add a small amount of table salt so that the flame burns a bright orange color. Large quantities (one-half liter or more) of alcohol or other flammable liquids should never be brought into the room, and students should never have access to quantities of these liquids. From *Science for Life and Living: Integrating Science, Technology, and Health - Systems and Analysis* by BSCS. Copyright (c) 1994 by BSCS. Used by permission of Kendall/Hunt Publishing Company.

14.3.3 Flammable Liquid Storage

If teachers are storing flammable liquids such as alcohol, they should do so only in small quantities in the manufacturer's original container or in an approved safety can. A safety can is made is heavy-gauge steel or polyethylene. It has a spring-loaded lid to prevent spilling and to vent during vapor expansion caused by a heat source. It also has a flame arrestor or heat sump in the throat of the spout to help prevent explosions.

14.3.4 Fire Blanket

Fire blankets should be of the proper type and size and in the proper location. They should not be so large that students could not easily use them in an emergency. Check to be certain that they are placed in conspicuous locations and easily retrievable by both disabled and nondisabled students and staff. Unless otherwise recommended by your fire marshal, these blankets should be made of wool. Fire blanket display and storage containers should be carefully checked for proper function. Be sure to eliminate containers with rusted hinges and latches, blankets still stored in plastic wrappers, and blankets made with asbestos fiber. Six-foot vertical standing fire blanket tubes should be avoided since they can result in facial burns. Do not attempt to extinguish torso fires by having a student stand and be wrapped in the fire blanket. This results in a chimney effect, which pushes heat across the student's face and causes unnecessary facial burns. The stop-drop-and-roll procedure endorsed by fire departments appears to be most effective at extinguishing body fires and presents the fewest drawbacks.

14.3.5 Fire Extinguishers

ABC triclass fire extinguishers are usually preferred by fire departments due to their ability to extinguish most foreseeable fires from products likely to be found in elementary science settings (such as paper products, electrical items, grease). See section 14.5.1. on fire fighting. In settings where microcomputers are used regularly, it might be wise to investigate halon extinguishers. These have been used in aviation for years because their fire-extinguishing chemicals do not foul the contacts in delicate electronic navigation and communications equipment and microcomputers as dry chemical types will. Halon has also been preferred over carbon dioxide for extinguishing fires within electronic equipment, such as computers, because it does not cause a cold thermal shock to sensitive electronic microcircuits. Teachers should confirm such suggestions with their local or state fire marshal. The major disadvantage to halon is its harmful effect on the earth's ozone layer. Since halon contains such small quantities of this ingredient and such emergency tools are used so infrequently, the benefits may outweigh the drawbacks. It is a good idea to have fire department personnel come into your room and demonstrate for students appropriate fire procedures and equipment. Teachers should be confident and comfortable in using their fire equipment items. Teachers should also be in the habit of checking the pressure valves on fire extinguishers in or near their rooms to ensure that they are still adequately pressurized. It would also be wise for students to heft extinguishers, unfold and use a fire blanket, and rehearse foreseeable emergencies involving fire.

14.3.6 Eyewash

It is recommended that fifteen minutes (2.5 gallons per minute) of aerated, tempered (60-90 degrees Fahrenheit) running water be deliverable from an eyewash to flush the eyes of a person who has suffered a chemical splash. At the elementary level, eye irritants could include salt, vinegar, sand, alcohol, and other chemicals. Teachers should explore the installation of the fountain fixture type of eyewash station. It is inexpensive ($60-$70) and easy to install. Screw it into an existing gooseneck faucet. The fixture allows the plumbing to be used as both an eyewash and a faucet simply by pushing a diverter valve. Should traffic patterns or room designs change, such fountain fixtures can easily be moved to other faucets. Check the equipment and chemicals reference section of this book for sources. On a temporary basis, educators can stretch a piece of surgical tubing over a gooseneck faucet in order to deliver aerated running water to the eyes of a chemical splash victim. Again, it is critical that such equipment be easily accessible to all staff and students. Be certain that the hot water faucet handle has been removed from any sink eyewash to prevent accidental burns caused by hot water. Bottled water stations are not recommended for use during science activities because they can be contaminated, and they cannot deliver fifteen minutes of aerated running water. They should only be used when there is no alternative, such as in field settings, and where the teacher maintains very strict control of them.

14.4 Eye Protection (refer to the Life Science Safety Manual section 14.2.2 for other protective equipment)

14.4.1 Eye Goggles

According to NSTA's "Safety in the Elementary Science Classroom," eye goggles protect against impact and splashes and reduce the amount of dust and fumes near or in the eyes. In order to establish an effective eye safety program, teachers should practice the following:

1. Demonstrate the proper way to wear safety goggles.
2. Require students to wear safety goggles whenever they use sharp objects, chemicals, or materials that could fly into someone's face. Such simple chemicals as vinegar and salt and objects such as rubber bands and toothpicks could pose potential risks of eye injury if students are not wearing safety goggles.
3. Assure that all persons performing science laboratory activities involving hazards to the eye wear approved eye protection devices. All persons in dangerous proximity to such activities must likewise be equipped.
4. Recommended safety goggles are those marked with the number "Z87" on the goggle's face. Such goggles meet the safety standards set by the American National Standards Institute.

14.4.2 Guidelines for Sanitizing Safety Goggles

The best way to ensure cleanliness of safety goggles is to assign one pair of goggles to each student in the class. Label the goggles with students' names, and insist that each student wear only his or her assigned pair. If students share goggles, you must clean and disinfect them after each use. Less expensive procedures for sanitizing goggles are described below:

1. Place a little dishwashing detergent in a dishpan or other large container. Fill it halfway with warm water. Make a bleach solution in a second dishpan, using 1/4 cup of bleach for each gallon of water. Swish the goggles in the soapy water, and then soak them in the bleach solution for 10 minutes. Rinse the goggles thoroughly in clean water, and let the goggles air dry. This process cleanses and disinfects the lenses and straps, although it might eventually cause the lenses to turn yellow and cloudy.
2. Purchase individually wrapped alcohol pads from a local pharmacy. The pads cost approximately 3 cents each and are available in boxes of 100. Wipe the lenses and straps of one pair of goggles with a fresh alcohol pad. Then dispose of the used pad in its original package. Allow the goggles to air dry.

14.4.3 Blindfolding

1. Maintain strict standards for cleanliness. If some blindfolding material is used for testing the senses, it should never be used on more than one child. Eye diseases are highly contagious.

14.5 Fire Prevention and Control

It is the responsibility of each science teacher to be prepared to act deliberately and intelligently in the event of a classroom fire. Your first concern should be to evacuate the area. It is important that you know not only the location of the fire fighting aids available - the blanket, the extinguishers, and the fire alarm box - but also how to use them. The principal concern in any materials fire is to immediately move students from the fire area. The teacher must quickly determine the immediate and potential danger from the fire. If there is any chance that the fire might spread or represent a danger to the classroom or students, the fire alarm must be sounded. It is the teacher's responsibility to know the location of the fire alarm box nearest the classroom. The first responsibility of teachers is to get students out of the area. Other common types of accidental fires in the science laboratory are those of clothes and hair when students lean too close to an open flame. In both cases, water is the most effective remedy. A fire blanket to smother the fire could also be used (see information on Fire Blankets, section 14.3.4). Do not use a CO_2 fire extinguisher on an individual. A CO_2 blast could spread the fire and possibly cause frostbite, thereby compounding the burn.

14.5.1 Fire Fighting

The use of the proper type of extinguisher for each of the four general classes of fires will provide the best control. The classification of fires here is based on the type of material being consumed.

Class A - Fires in wood, textiles, paper, and other ordinary combustibles. This type of fire is extinguished by cooling with water or a solution containing water (loaded steam) which wets down the material and prevents glowing embers from rekindling. A general purpose dry chemical extinguisher is also effective by fusing and insulating.

Class B - Fires in gasoline, oil, paint, or other flammable liquids that gasify when heated. This type of fire is extinguished by smothering, thus shutting off the air supply. Carbon dioxide, dry chemical, and foam are effective on this type of fire. To use a dry chemical or carbon dioxide extinguisher, pull the pin, point the nozzle at the flame, and squeeze the handle. Do not hold the horn of the carbon dioxide extinguisher with your hands; use the handle since the carbon dioxide causes supercooling of the horn.

To use a foam extinguisher, invert the extinguisher and point the nozzle in such a way as to cause the foam to float over the fire; do not point the stream at the flame. The extinguisher does not have a cut-off valve and must be completely expelled.

Class C - Fires in live electrical equipment. Whenever possible, the source of power to the burning equipment should be cut off. A Class "C" fire is extinguished by using a nonconductive agent. A carbon dioxide extinguisher smothers the flame without damaging the equipment. A dry chemical extinguisher is also effective.

Class D - Fires in combustible materials such as magnesium, titanium, zinconium, sodium, potassium, and others. This new and somewhat specialized classification is extinguished by a special extinguisher powder which is applied by a scoop, unlike general purpose dry chemicals. Dry sand may also be applied with a scoop to extinguish small Class D fires.

14.6 First Aid

First aid is the immediate care given to a person who has been injured or has suddenly taken ill. Its purpose is to protect rather than treat and it is used in emergency situations where medical assistance is not immediately available. It is the responsibility of each teacher to know how to proceed in the event that a student becomes ill or is injured in the classroom. All teachers should receive first aid training from the American National Red Cross. Listed below are safety, emergency, and first-aid tips in the case of an accident. Keep in mind that the recommendations below may vary with individual schools. The specific procedures for your school should be followed.

14.6.1 Safety and Prevention

1. Have first aid procedures established in the event of an accident.
2. All students and teachers should know the location of fire extinguishers, eyewash fountains, fire blankets, and first aid kits.
3. Safety signs should identify the location of safety equipment.
4. Emergency instructions concerning fire, explosions, chemical reactions, spillage, and first aid procedures should be conspicuously posted near all storage areas.
5. Safety posters are encouraged in science laboratories.

14.6.2 Emergency

In the event of an accident or injury, take the following steps immediately:

1. Notify the school principal.
2. Have a properly trained person administer first aid, if necessary.
3. Notify the school nurse.

14.6.3 Serious injury

1. Immediately obtain medical help by calling a predetermined emergency number, or the police or fire department.
2. Establish contact with the parents or guardian as soon as possible and urge that they contact their family physician immediately.
3. If not able to reach parents or guardian, contact the alternate person designated and/or the family physician directly.
4. Give first aid. Do not treat or provide medication.

14.6.4 First Aid

1. KEEP CALM and keep crowds away from the injured student(s). Obtain staff assistance - send for the school nurse and principal. Handle the person as little as possible until the injury evaluation is complete and moving may be indicated. Do nothing else unless you are certain of the correct procedure.
2. RESTORE BREATHING. Restoration of breathing may be accomplished by using one of the methods listed below in which you have had sufficient training:
a. Mouth-to-mouth (mouth to nose) method
b. Cardiopulmonary resuscitation (CPR)
c. Heimlich Maneuver Technique (in the event of choking) for clearing obstruction of the airway
3. STOP ANY BLEEDING. The following steps should be taken for either massive or slight to moderate bleeding:
a. If bleeding is severe or profuse, it must be stopped before other aid can be given. Apply a large compress to the wound with direct pressure using the heel of the hand.
b. If the cut is slight and bleeding is not profuse, remove all foreign material (glass, dirt, etc.) projecting from the wound (but do not gouge for imbedded material). Wash with large amounts of water and apply sterile dressing.
4. PREVENT SHOCK. Symptoms are paleness, cold and moist skin with perspiration on the forehead and palms of the hands, nausea, shallow breathing, and trembling.

a. Place the victim in a reclining position with the head lower than the body, unless victim is having difficulty breathing.
b. Control any bleeding by applying direct pressure.
c. Wrap with blankets, coats, paper, etc.
d. Keep the victim's airway open.
It is essential to obtain medical aid in every case of serious injury or illness, in all cases of injury to the eye, and whenever in doubt. School employees should not diagnose, prescribe, treat, or offer medication, but may render first aid.

References

American National Red Cross. (1973). *Standard First Aid and Personal Safety.* Garden City,
NY: Doubleday & Company.
Biological Sciences Curriculum Study. (1992). *Science for Life and Living; Integrating Science,*
Technology, and Health. Dubuque, IA: Kendall/Hunt (pp. T37, T38, & T40).
Martin, R.; Sexton, C.; Wagner, K.; & Gerlovich, J. (1994). *Teaching Science for All Children.*
Needham Heights, MA: Allyn and Bacon (pp. 346-355).
National Science Teachers Association Subcommittee on Safety. (n.d.). Safety in the Elementary
Science Classroom [Brochure]. Washington, D.C.: National Science Teachers Association (pp.
1-11).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC:
Holt, Rinehart, & Winston (pp. 5-26).
6. North Carolina Department of Public Instruction. (n.d.). Elementary Science Safety Guide
[Brochure]. NC: Author (pp. 1-3).

14.7 Animals in the Classroom

The use of live animals in the classroom is essential if students are to fully understand and appreciate life processes. Students need ample opportunities to observe and experiment with living organisms at all levels in the curriculum. Good safety procedures should be established for the protection of students from the hazards of classroom animals as well as to ensure the humane treatment of animals.

The humane treatment of animals in research and teaching is becoming a more and more sensitive issue. The Council of State Science Supervisors, the National Association of Biology Teachers, the National Science Teachers Association, the Humane Society of the United States, the Animal Welfare Institute, and the National Society for Medical Research, all have established guidelines and position papers supporting the safe and humane treatment of animals used for the cause of science.

While many types of invertebrates and vertebrates can be kept successfully in the classroom, several factors should be considered before acquiring any animal and embarking on such a venture. Because of their diversity, it is difficult to generalize about their characteristics and habits, but their diversity is what makes them exceptionally interesting to study. Many of them can be kept or raised in captivity; organisms used in the classroom are selected because of their popularity with children, their availability, their easy care, their unique habits, or their usefulness as a source of food for other classroom animals. Although general safety measures apply for the handling and care of most animals, knowing your organism's specific needs will encourage its proper care.

It is important that students and teachers exercise proper collection, handling, and maintenance of all animals. Specific manuals for maintaining organisms in the classroom are available for purchase and use in the classroom. Planning is essential, not only for providing meaningful learning experiences for students, but for the welfare of the animal involved.

14.7.1 General Classroom Animal Safety Guidelines

Before introducing animals into the classroom, the policy of your local school district should be checked. When animals are in the classroom, care should be taken to ensure that neither the students nor the animals are harmed. Mammals protect themselves and their young by biting, scratching, and kicking. Pets such as cats, dogs, rabbits, and guinea pigs should be handled properly and should not be disturbed when eating. The following are some points to consider and classroom rules you may wish to adopt for invertebrates and vertebrates.

1. Do not allow students to bring live or deceased wild animals, snapping turtles, snakes, insects, or arachnids (ticks, mites) capable of carrying disease into the classroom.
2. Before a small animal is brought into the classroom for observation, plans should be made for proper habitat and food. These habitats must be kept clean and free from contamination, and animals must remain in a securely closed cage. Provisions for their care during weekends and holidays must be made.
3. When purchasing animals, purchase only from a reputable supply house. Fish should be purchased from tanks in which all fish appear healthy.
4. Discourage students from bringing personal pets into school. If they are brought into the room, they should be handled only by their owners and provisions should be made for their care during the day by providing fresh water and a place to rest.
5. When observing unfamiliar animals, students should avoid picking them up or touching them.
6. Caution students never to tease animals, nor to insert their fingers or objects through wire mesh cages. Report animal bites and scratches immediately to the school's medical authority. Provide basic first aid.
7. Animals should be handled only if it is necessary. This handling should be done properly according to the particular animal. Rats, rabbits, hamsters, and mice are best picked up by the scruff of the neck, with a hand placed under the body for support. If young are to be handled, the mother should be removed to another cage. By nature she will be fiercely protective. Special handling is required if the animal is excited, feeding, pregnant, or with its young.
8. Use heavy gloves for handling animals and have students wash their hands before and after they handle animals.
9. Any student who is bitten or scratched by an animal should report immediately to the school nurse.
10. Each study involving animals should have as a clearly defined objective the teaching/learning of some scientific principle(s).
11. All mammals used in a classroom should have been inoculated for rabies, unless

purchased from a reliable scientific company (this applies to domestic animals as well).
12. After a period of observing an animal brought in from the natural environment (i.e. toad, insect, etc.), it should be returned to its natural environment.
13. Individual animals require different environments to survive, and being knowledgeable about your animal's needs will encourage proper care behaviors by you and your students.
Selections below were obtained from the U.S. Humane Society Guidelines:
14. In vertebrate studies, palatable food shall be provided in sufficient quantity to maintain normal growth. Diets deficient in essential foods are prohibited. Food shall not be withdrawn for periods longer than 12 hours. Clean drinking water shall be available at all times (and shall not be replaced by alcohol or drugs).
15. Birds' eggs subjected to experimental manipulations shall not be allowed to hatch; such embryos shall be killed humanely no later than the nineteenth day of incubation. If normal egg embryos are to be hatched, satisfactory arrangements must be made for the humane disposal of chicks.
16. The comfort of the animal observed shall receive first consideration. The animal shall be housed in appropriate spacious, comfortable, sanitary quarters. Adequate provision shall be made for its care at all times, including weekends and vacation periods. The animal shall be handled gently and humanely at all times.
17. Respect for life shall be accorded to all animals, creatures, and organisms that are kept for educational purposes.

14.7.2 Animal Environments and General Maintenance

Each kind of animal has its own unique combination of environmental requirements that include habitat, food, water and climate. An animal's comfort in captivity and perhaps its survival depend to a great extent on the degree to which these needs are provided for or simulated. Listed below are suggestions for general environments necessary for maintaining animals in the classroom.

14.7.2.1 Animal Environments: Cages, Terrariums, Aquariums, and Jars - Below is a list of general tips for housing animals outside of their natural environment.

1. Enclosure should have easy access for the keeper to provide food, water, and general care and cleaning.
2. The environment should provide good visibility for the observer since it is intended to be used as a learning experience.
3. The environment should provide for the animal's basic needs (food and water) and comfortability. No single kind of environment meets the needs of all animals and habitat compromise might be necessary. Compromises should always be in favor of the well-being of the animal.
4. Avoid too much heat in an animal environment. High temperatures lower the oxygen concentration in water and increase the metabolic activity of organisms and thus increase their rate of oxygen consumption.
5. Unless culture methods specify otherwise, maintain a loose cover over all cultures to prevent contamination with dust and unwanted microorganisms.
6. Care should be taken to ensure that homemade cages are free from potentially harmful substances such as wood preservatives, paints, and adhesives and that there are no sharp edges or protruding nails that might cause injury to an animal.
7. Normal classroom lighting will meet the needs of most animals. Provide light for the

animal either on a 12-hour timer or by moving the cage to a room with a window for the weekend.

8. Normal classroom temperatures are within the satisfactory range for most animals, even though ideal conditions may be slightly warmer or cooler. If the building temperature is reduced overnight or on weekends (temperature falls below 60 to 65 degrees F), special arrangements must be made.
9. Depending on the organism, humidity may need to be regulated.
10. It is important to clean the animal's environment regularly to promote good sanitation practices.
11. All cultured organisms living in a very limited space use up their food supply, overpopulate, and accumulate toxic wastes or offensive products fairly rapidly. These cultures must be routinely fed, cleaned, and transferred.

14.7.2.2 Specific Information on Man-made Environments - Use the following tips to help care for plants and animals in the classroom.

1. A glass cover over a terrarium or aquarium will reduce evaporation and maintain a higher humidity level.
2. Especially in terrariums, plants may be kept in pots to allow easy removal and replacement and decrease the amount of uprooting.
3. When housing snakes, a screen-covered terrarium containing only the captive is suggested.
4. Do not use metal lids with nail-punched holes. Nail holes punched in metal jar lids are sharp and potentially dangerous. Punched inward, they can cause serious injury to an animal. Punched outward, they can cut fingers. Use screen covers instead.

14.7.3 Collecting Specimens

14.7.3.1 Limiting Your Collection - There are several reasons to limit your collection of organisms:

1. To model respect for all living things.
2. To model that all organisms are best studied in their natural environment without interference from observers.
3. To keep from impacting the organisms in the area, especially if many classes visit the same site.
4. To avoid making the main focus of the activity collecting animals instead of understanding ecological concepts.

14.7.3.2 General Recommendations - If you determine that you want your students to collect some organisms for closer observation, several recommendations are listed below:

1. Never collect material from an area unless you have permission from the person or organization who owns the land. You should not collect any material from national or state parks.
2. Never collect rare or endangered species. Someone at your State Department of Natural Resources or local cooperative extension service should be able to tell you if there are any such species in your area. See your phone book for the telephone numbers of these agencies.
3. Instruct students to minimize the number of organisms they collect.
4. Place all containers away from direct sunlight.
5. If aquatic animals are collected, use water for the containers from the area where the organisms were found. If the water in the containers with aquatic animals becomes

warm, replenish with cool fresh water.
Refer to general classroom animal safety guidelines (14.7.1) for other information regarding the collection of animals.

14.7.4 Animal Disposal

When animals are no longer wanted or needed in the classroom, they must still be dealt with in a responsible way. Animals that have been collected locally can be released back into their natural habitats, provided that the weather has not changed significantly. However, animals that are not native to a given area or animals that have been purchased (even if they are thought to be native to the area) should not be released. Non-native animals released into the local area may suffer and die if the environment is inappropriate. If they survive and become established, they can create serious ecological and environmental damage. Sometimes animals are given to other teachers who can use them for educational purposes. Many times, students will want to take a classroom animal home as a personal pet; but, of course, this should only be permitted with parental approval and if it is certain that both the child and the parent are knowledgeable about the animal's needs. A pet store might also accept (and will sometimes purchase) a healthy animal for resale. The store might also be interested in insects such as crickets or mealworms that can be used as food for other animals. Refer to the Biology Laboratory Safety manual for guidelines regarding humans as experimental organisms and on information concerning the obtaining, use, dissection, storage, and disposal of living and preserved animals.

References

American Forest Foundation. (1993). *Project Learning Tree: Pre-K-8 Activity Guide* (2nd ed.).Author.
Hampton, C. D.; Hampton, C. H.; Kramer, D.; and others (1986). *Classroom Creature Culture: Algae to Anoles.* (Rev. ed.). Arlington, VA: National Science Teachers Association (pp. 6-11).
Humane Society of the United States (n.d.). *HSUS Guiding Principles for Use of Animals in Elementary and Secondary Education.* Washington, D.C.: Author.
Kneidel, S. S. (1993). *Creepy Crawlies and the Scientific Method.* Golden, CO: Fulcrum.
Kramer, D. (1989). *Animals in the Classroom.* Menlo Park, CA: Addison-Wesley (pp. 1-26).
National Science Teachers Association Subcommittee on Safety. (n.d.). Safety in the Elementary Science Classroom [Brochure]. Washington, D.C.: National Science Teachers Association (pp. 1-11).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC:
Holt, Rinehart, & Winston (pp. 5-26).
Pratt-Butler, G. K. (n.d.). *How to Care for Living Things in the Classroom.* Washington, D.C.:
National Science Teachers Assocation.
Smith, D. C. (1960). Small Animals in the Classroom. *The American Biology Teacher*, 22, 471-477.

14.8 Plants in the Classroom

Teachers are encouraged to create a classroom environment where there are plants for students to observe, compare, and possibly classify as a part of their understanding of the plant world. Plants that are used for such purposes should be well known to the teacher. Below are general safety guidelines for the use of plants in the classroom.

14.8.1 General Plant Safety Guidelines

1. Become familiar with dangerous plants in your environment.
2. Remember there are no "safe tests" or "rules of thumb" for distinguishing nonpoisonous from poisonous plants.
3. Breathing spores or pollen can cause reactions in many individuals which may later lead to allergies or diseases.
4. Adhere to the rules regarding poisonous plants in Section 14.8.4.

14.8.2 General Plant Care

The following is a list of ways to maintain plants in the classroom:

1. Never collect a plant if it's the only one growing in a particular area. Instead, collect plants that are growing in groups or stands.
2. Plants should be placed under fluorescent lights or near a window exposed to full sunlight at least part of the day.
3. The use of botanical or synthetic pesticides is strongly discouraged in the classroom.
4. Always take infected plants outdoors for treatment so students aren't exposed to chemicals.
5. Store pesticides in their original containers in a locked cabinet or room out of reach of children.

Refer to section 14.7.2 on Animal Environments and General Maintenance.

14.8.3 General Disease Prevention Methods

The most important means of avoiding disease and pest problems is to prevent them from becoming established. This means being vigilant, providing conditions for healthy plants, and practicing strict classroom garden hygiene as described below (recommendations adopted from the National Gardening Association's "Grow Lab").

1. Pay attention to the plants; investigate the soil, the underside of leaves, etc., for potential problems.
2. When you plant seeds, make sure your potting mix isn't so wet that you can wring water out of it, because algae and fungi will develop in the wet environment. When you water, avoid splashing or wetting the leaves for the same reason.
3. Don't bring in house plants that could have diseases or insect problems. If you must bring in house plants, reduce the risk by inspecting them carefully and by quarantining the newcomers in another part of the room for a few weeks.
4. Remove damaged, diseased, or weakened plant materials regularly from the indoor garden, because they attract insects and provide ripe conditions for diseases to develop.
5. Maintain good air circulation within the garden.
6. Disinfect your equipment.
7. Always use clean potting mix. Reusing potting mix, unless you have pasteurized it, will invite trouble. Commercial soil mixes are already sterile.
8. Fertilize properly. Too much fertilizer can cause lush growth which will be weak and extremely susceptible to attack.
9. Don't touch plants when they're wet. When the leaves of your plants are wet, touching them can spread waterborne diseases.
10. Use good watering practices. Watering too often deprives the roots of air and promotes rotting. Not watering enough stresses the plants and makes them more

susceptible to disease and insects.
11. Don't wait if you notice a problem developing. Take action immediately before the problem has a chance to become well-established and spread to other plants.
12. Dispose of empty pesticide containers properly. Don't reuse them for any purpose. Rinse thoroughly several times and use the rinse water as a last spray on your plants. Wrap empty containers in several layers of newspaper before putting them in the trash.

14.8.4 Poisonous Plants

Since many plants have not been thoroughly researched for their toxicity, the following are some common precautionary rules to impart to your students:
1. Never place any part of a plant in your mouth. (Note: Teachers may want to emphasize the distinction between edible plants, fruits and vegetables, and non-edible plants).
2. Never allow any sap or plant juice to set into your skin.
3. Never inhale or expose your skin or eyes to the smoke of any burning plant.
4. Never pick any unknown wildflowers, seeds, berries, or cultivated plants. If necessary, use gloves to touch unknown plants.
5. Never eat food after handling plants without first scrubbing your hands.

The reasons for these precautions are that any part of a plant can be relatively toxic, even to the point of fatality. The following are some specific examples of toxic plants. This list was obtained from NSTA's "Safety in the Elementary Science Classroom" and is only partial; teachers should include additional poisonous (toxic) plants for their specific geographical area. Also, be aware that many common house, vegetable garden, wooded area, swamp or moist area, ornamental, and field plants, trees and shrubs are toxic.

14.8.4.1 Plants which are poisonous to the touch due to exuded oils:
a. Poison ivy (often found on school grounds)
b. Poison oak
c. Poison sumac
d. Stinging nettles
e. (other)

14.8.4.2 Plants which are poisonous when eaten:
a. Some fungi (mushrooms)

b. Aconite
c. Belladonna
d. Wake robin
e. Henbane
f. Pokeweed
g. Tansy
h. Foxglove
i. Indian tobacco
j. Jimson weed
k. (other)

14.8.4.3 The saps of the following plants are toxic:
a) oleander,
b) poinsettia,

c) trumpet vine and
d) other.
Refer to section 13.2.3 in the Biology Laboratory Safety manual for other cautions regarding plant handling and care, and to the Family Safety Magazine of the National Safety Council for a list of common poisonous plants.

14.8.5 Plant Diseases

The best way to avoid disease problems is to provide ideal conditions (good air circulation, watering, and fertilizing practices, etc.) for your indoor garden and to practice strict garden hygiene. It's difficult to eradicate diseases once they become established, so prevention pays off!

Below are a list of disease problems and control mechanisms obtained from the National Gardening Association's "Grow Lab."

DISEASE CONTROL

1. Powdery Mildew - Leaves appear dusted Increase air circulation by uncovering with white powder and eventually turn brown garden. Allow the garden to dry and wither, killing the plant. out between waterings.
2. Gray Mold - Plants develop brown patches Clean up dead plant debris. Remove that eventually are covered with gray or brown and discard all affected materials to fuzzy mold. It can migrate to healthy plants. prevent spreading.
3. Damping off - This fungal disease causes Cover newly planted seeds with 1/8 seedling to rot suddenly at the soil line and inch sphagnum peat moss. Remove fall over. It may prevent germination and affect affected plants and the soil around them flowering and vegetable seed plants. Discard/sterilize potting mix and containers where affected plants were growing.
4. Bean Mosaic - This viral disease is carried No control - prevent by keeping by aphids or seeds of infected plants. Bean leaves aphid population down. Remove appear puckered, yellow, and die. It weakens the affected plants immediately.
5. Fungi and Algae - Fuzzy white, dry brown, or If you notice growths, stir soil or green (algae) growths appear on the soil or base base material with a fork or fingers material surface. They're not real problems, but once a week. Also, dry out garden indicate moist conditions and poor air circulation, by uncovering it to increase air which could lead to other problems. circulation. To avoid algae growth, cover exposed portions with aluminum foil, heavy cardboard, or dark plastic sheets.

14.8.6 Plant Disposal

Teachers should be aware of appropriate plant disposal methods, especially with exotic or nonnative plants. Refer to Biology Laboratory Safety 13.2.4 for general disposal procedures and 13.2 for other considerations regarding the care and use of plants.

References

Hampton, C. D.; Hampton, C. H.; Kramer, D.; and others (1986). *Classroom Creature Culture: Algae to Anoles.* (Rev. ed.). Arlington, VA: National Science Teachers Association (pp. 6-11).

National Gardening Association. (1988). *National Gardening Association Grow Lab; A Complete Guide to Gardening in the Classroom.* Burlington, VT: Author (pp. 58-63).

National Science Teachers Association Subcommittee on Safety. (n.d.). Safety in the Elementary Science Classroom [Brochure]. Washington, D.C.: National Science Teachers Association (pp. 1-11).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC: Holt, Rinehart, & Winston (pp. 5-26).

14.9 Microorganisms in the Classroom

It is important to practice good safety measures when handling microorganisms in the classroom. Refer to the Biology Laboratory Safety manual 13.4.1 for further information regarding the use and safety of microorganisms in the classroom. Below are general safety guidelines regarding the use of microorganisms in the classroom.

14.9.1 General Microorganism Safety Guidelines

1. Only nonpathogenic bacteria should be used in the classroom. Indiscriminate culturing and handling of pathogenic or nonpathogenic organisms are discouraged.
2. Petri dish cultures should be sealed with tape.
3. Bacterial cultures should be killed before washing petri dishes. Most cultures can be killed by heating for 20 minutes at 15 pounds/inch squared (138 kPa) of pressure or by flooding the surface with chlorine bleach.
4. Contaminated culture media should be sterilized with a strong disinfectant and washed with a strong cleaning agent.
5. Always flame wire loops prior to and after transferring organisms.
6. Wear proper equipment (apron and rubber gloves) when washing bacteriological or chemical ware.
7. Use utmost caution when using a pressure cooker for sterilization of equipment. Turn off the heat source, remove the cooker, and allow the pressure to gradually reduce to normal atmospheric pressure prior to removing the cover.
8. When using the microscope, students should never use the mirror to reflect direct sunlight through the microscope. The bright light can cause permanent eye damage.
9. All live protozoan cultures should be maintained in bright light, but not direct sunlight. Jar lids should be loose so that oxygen can circulate. If an infusion develops mold, tighten the lid and discard it.
10. Students should be instructed that it is unsafe to touch the face, mouth, eyes, and other parts of the body while they are working with plants, animals, microorganisms, fungi, or chemical substances and afterwards, until they have washed their hands and cleaned their nails.
11. Be aware of any allergies that students might have to certain foods, plants, fungi, microorganisms, chemicals, or other substances used in class. For example, breathing spores or pollen can cause reactions in many individuals which may later lead to allergies or diseases.
12. Molds grown or discarded in bags should be killed first before they are thrown away.

Refer to the Biology Laboratory Manual, section 13.0, for more information regarding the use of microorganisms in the classroom.

References

Biological Sciences Curriculum Study. (1992). *Science for Life and Living; Integrating Science, Technology, and Health.* Dubuque, IA: Kendall/Hunt (pp. T37, T38, & T40).

National Science Resources Center. (1991). *Microworlds.* Burlington, NC: Carolina Biological.
National Science Teachers Association Subcommittee on Safety. (n.d.). Safety in the Elementary Science Classroom [Brochure]. Washington, D.C.: National Science Teachers Association (pp. 1-11).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC: Holt, Rinehart, & Winston (pp. 5-26).

14.10 Earth Science in the Classroom

Proper safety precautions are necessary when students are engaged in Earth Science related activities in the classroom. General information on earth science safety in the classroom is found in *Rocks and Minerals*, and Champaign Unit 4's *Our Place In Space* for information on solar safety.

14.10.l General Safety Guidelines

14.10.1.1 Rocks, minerals - Proper protective devices (eyes, body) should be used when hammering, chipping, or grinding rocks, minerals, or metals. See section 14.4 for further information on eye protection and rocks and minerals.

14.10.1.2 Solar system - The following suggestions will help students protect their eyes when they study the solar system.

1. It is extremely dangerous to look at the sun with the naked eye or even very dark sun glasses. Eye damage or blindness may occur.
2. Never use optics such as binoculars or telescopes to look at the sun. This only magnifies the intensity of the sun and can cause permanent damage or blindness.
3. Looking at an eclipse of the sun is even more dangerous because of the intensity of light. This can only be done safely by experts.
4. Use proper illumination for microscopes. Reflected sunlight can damage the eye.

References

Champaign Community Schools Unit District #4. (1996). *Our Place in Space.* Champaign, IL: Author (p. 5).
From *Science for Life and Living: Integrating Science, Technology, and Health - Systems and Analysis* by BSCS. Copyright (c) 1994 by BSCS. Used by permission of Kendall/Hunt Publishing Company.
National Science Resources Center. (1994). *Rocks and Minerals.* Burlington, NC: Carolina Biological.

14.11 Physical Science in the Classroom

Below are general safety measures regarding the storage of equipment and materials and the handling and maintenance of various equipment and chemicals. It is important that teachers and students follow proper procedures when dealing with potentially dangerous equipment and chemical substances.

14.11.1 Storage of Equipment and Materials

Poor storage invites accidents. One of the most important essentials for safety in the classroom is adequate, efficiently planned storage. The following should be considered when storing equipment and materials.

14.11.1.1 Area - Enough space should be available so that there is no crowding. Shelving should deep enough that the articles are not easily dislodged. A bar on the shelf edge is often desirable as an added safety measure to prevent items from falling off.

14.11.1.2 Height of Storage Shelves - Low levels are preferred. Toxic chemicals, large glassware, and heavy articles should always be stored on a lower shelf that is not accessible to students. When shelving cannot be reached from a standing position, a step stool should be available and used.
14.11.1.3 Containers - Materials should be kept in containers which are easily handled, e.g., acids are kept in small bottles for student use rather than in large gallon jars. Plastic is preferrable to glass because of breakage.
14.11.1.4 Placement of Hazardous Materials - Volatile liquids should be stored away from
sunlight, electrical switches, or heat sources. Reacting chemicals should not be stored near each other. Hazardous materials should be kept under separate lock.
14.11.1.5 Labeling - At the elementary school level, it is prudent to label both the storage area where the equipment and materials are stored as well as the individual item. Marking pens or electric markers may be used to identify equipment name. Usually temporary type labels are more appropriate for containers used for materials, including dry and liquid chemicals.
14.11.1.6 Dispensing - Teachers should dispense substances into temporarily marked containers for student use and only in such quantities as will be used. Pouring dry chemicals or liquids back into the original containers will almost certainly contaminate the entire supply.
14.11.1.7 Identification of Chemicals - Chemicals should be identified by common name as well as the scientific name, formula, precautions for use, and antidote. Substances which have lost their identity labels or for which there is confusion as to their identity should be carefully discarded. They should never be used in experiments.
14.11.1.8 Liquid storage - Liquids should be stored in separate storage areas, not near equipment or other materials. Storage should further be separated by placing acids, bases, and salts in separate areas. Volatile substances, if any, should be placed in a cool storage area that has proper ventilation.
14.11.1.9 Transportation and Control - A system should be developed for transporting equipment and materials to the classrooms. A rolling cart with lips on each shelf is highly recommended. Hazardous materials should only be transported through the halls under direct supervision of a teacher. In addition, a method for checking in and out what is needed should be put into practice.
Refer to Chapter 7 for more detailed information regarding storage and labeling of chemicals.

14.11.2 General Safety Guidelines

14.11.2.1 General - Below are general safety tips when doing physical science related activities in the classroom:

1. Constant surveillance and supervision of students activities are essential.
2. Teachers should set good safety examples when conducting demonstrations and experiments.
3. Always practice activities yourself before performing them with your class. This is the only way to become thoroughly familiar with an activity, and familiarity will help prevent potentially hazardous mishaps. In addition, you may find variations that will make the activity more meaningful to your students.

4. Read each activity carefully and observe all safety precautions and disposal procedures.
5. Special safety instructions are not always given for everyday classroom materials being used in a typical manner. Use common sense when working with hot, sharp, or breakable objects such as flames, scissors, or glassware. Keep tables or desks covered to avoid stains. Keep spills cleaned up to avoid falls.

14.11.2.2 Match Safety

1. Only wooden safety matches, the kind sold in packets of small individual boxes, should be used. Book matches are not recommended.
2. Be sure the box is closed before the match is struck.
3. Always strike the match away from you.
4. Strike the match near the candle you are going to light.
5. If the match breaks while you are trying to light it, don't use it. Dip it into water and place it in a jar.
6. If the candle has not lit and the match is burning low, blow the match out and get another.
7. After the match has been used, dip the hot end into water and place it in a jar.

14.11.2.3 Plastics

Below are general safety procedures that should be followed when handling plastic materials in the classroom:

1. If you are going to try breaking plastics with something like a hammer, wrap them in a cloth first because you don't know how they will behave.
2. Polystyrene, as used in clear “glasses” or other containers which give a ring when tapped, shatters with very jagged edges so take care.
3. When cleaning plastic tubes or boxes, remove caps and place the emptied tubes/boxes and caps in a dish with a solution of warm water and detergent. After the tubes have soaked at least ten minutes, push the large bottles brush up and down in the tubes to clean them.
4. Repair plastic box cracks using liquid plastic cement. The cement is applied by painting it on both sides of the crack. Several applications may be necessary in some instances. Allow one hour for drying.

14.11.2.4 Glass Tubing - See the chemistry chapter, section 9.1.1, on the safe use of glassware in
the classroom.

14.11.3 Physical and Chemical Science

14.11.3.1 General Guidelines - The following guidelines will help students use equipment and substances safely in the classroom.

1. Students should be taught that chemicals must not be mixed "just to see what happens."
2. Students should be instructed never to taste chemicals and to wash their hands after use.
3. Students should not be allowed to mix acid and water
4. Combustible materials should be kept in a metal cabinet equipped with a lock.
5. Chemicals should be stored under separate lock in a cool, dry place, but not in a refrigerator.

6. Only minimum amounts of chemicals should be stored in the classroom. Any materials not used in a given period should be carefully discarded, particularly if they could become unstable.
7. Never eat or drink in the laboratory or from laboratory equipment.
8. Never allow the open end of a heated test tube to be pointed toward anyone.
9. When alcohol is heated, it must be in a water bath container with the top of the beaker, etc., holding the alcohol below the top of the water bath container.
10. Chemicals should not be tasted for identification purposes.
11. When heating materials in glassware by means of a gas flame, the glassware should be protected from direct contact with the flame through use of a wire gauze or asbestos-centered wire gauze.
12. When working with flammable liquids
- Have a carbon-dioxide or multipurpose fire extinguisher available,
- Work in a well-ventilated area,
- Keep the liquid over a pan or sink,
- Use no flames or high-temperature heating devices, and
- Do not store in a home-type refrigerator. Fumes may be ignited by sparks produced in the electrical switching system. *(Explosion-proof refrigerators are available from science supply houses.)*
13. Alcohol lamps are not recommended for use in the classroom.
14. Thermometers for use in the elementary classroom should be filled with alcohol, not mercury.
15. When working with chemicals, it is imperative that teachers understand the properties, hazards, and appropriate emergency procedures to follow in the event of an accident. *Material safety data sheets (MSDS) and the Merck Index provide this comprehensive information from chemical manufacturers, including physical property data, toxicity information, and handling and disposal specifications for chemicals.*

14.11.3.2 Toxic Chemicals

1. Rubbing alcohol is known to be toxic to the intestines and is intended for external use only. Be sure to discard the used mixture after each class by pouring it down the sink drain.
2. Iodine is considered toxic when ingested in large quantities. Students should be warned not to put iodine in their mouth, as it is poisonous. Also, it can stain paper and clothes. To remove iodine stains, soak the item in a mixture of vitamin C and water.
3. Never mix products containing ammonia with chlorine bleach, toilet bowl cleaners, rust removers or oven cleaners. These products will produce poisonous gases when combined.

Refer to Chapter 8 in the Chemistry Laboratory Safety section for information on proper disposal of chemical substances.

14.11.4 Electrical Science

Teachers and students should be constantly alert to the following safety precautions while working with electricity.

1. Students should be taught safety precautions for use of electricity in all everyday situations.
2. At the start of any unit on electricity, students should be told not to experiment with the electrical current of home circuits.

3. Check your school building code about temporary wiring for devices to be used continuously in one location. Friction of extension cords could easily cause a short circuit.
4. Connecting cords should be short, in good condition, and plugged in at the nearest outlet.
5. To remove an electrical plug from its socket, pull the plug, not the electric cord.
6. Tap water is a conductor of electricity. Students' hands should be dry when touching electrical cords, switches, or appliances.
7. Students should understand that the human body is a conductor of electricity.
8. Batteries or cells of 1.5 volts or less are safe for elementary classroom use. However, the battery may explode if heated or thrown into an open fire. The chemicals inside the battery can be dangerous if taken internally or exposed to the skin.
9. Work areas, including floors and counters, should be dry.
10. Do not use electrical wires with worn insulation.
11. Use 3-prong service outlets.
12. Some D-cell batteries used in the classroom will not give even a mild shock unless more than two dozen are connected in a series. However, these batteries can generate significant amounts of heat if a wire is connected to both ends, and can cause burns. Teachers and students should take proper precautions when using D-cell batteries.
13. Do not use rechargeable batteries. These batteries can cause wires to be very hot when they are short-circuited.
14. Never grasp any electrical device which has just been used. Most electrical devices remain hot after use and serious burns may result.

References

Champaign Community Schools Unit District #4. (1991). *Mystery Powders; Third Grade Teacher's Guide.* Champaign, IL: Author (pp. 6-7).
Elementary Science Study. (1967). *Teacher's Guide for Gases and Airs - Nature of Air and Behavior of Gases.* NY: McGraw-Hill (pp. 23-24).
Elementary Science Study. (1988). *Teacher's Guide for Heating and Cooling.* Nashua, NH: Delta Education.
Illinois Environmental Protection Agency. (1993). Recipes for a Safer Home [Brochure]. IL: Author (p. 4).
Martin, R.; Sexton, C.; Wagner, K.; & Gerlovich, J. (1994). *Teaching Science for All Children.*
Needham Heights, MA: Allyn and Bacon (pp. 346-355).
National Science Resources Center. (1991). *Magnets and Motors - Science and Technology for Children.* Burlington, NC: Carolina Biological.
National Science Resources Center. (1994). *Food chemistry - Science and Technology for Children*. Burlington, NC: Carolina Biological.
National Science Teachers Association Subcommittee on Safety. (n.d.). *Safety in the Elementary Science Classroom* [Brochure]. Washington, D.C.: National Science Teachers Association (pp. 1-11).
North Carolina Department of Public Instruction. (n.d.). Elementary Science Safety Guide [Brochure]. NC: Author (pp.1-3).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC: Holt, Rinehart, & Winston (pp. 5-26).

Sarquis, J. L.; Sarquis, M.; & Williams, J. (1995). *Teaching Chemistry with Toys: Activities for Grades K-9*. Middletown, OH: Terrific Science Press.
Science 5/13. (1974).
Children and Plastics, Stages 1, 2 and Background. NY: Macdonald Educational (pp.33-34).

14.12 Art in the Classroom

The Toxic Art Supplies in Schools Act (P.A. 84-725) prohibits the purchase of toxic art and craft materials for the use in grades kindergarten through six. The act further requires that art and craft materials containing toxic substances purchased for use by students in grades seven through twelve be labeled in accordance with Section 5 of the Act. In addition, federal law regarding non-toxic art supplies became effective November 18, 1990. (See 15 U.S.C. 1277.)

In accordance with Sections 9 and 10 of the Toxic Arts Supplies in Schools Act, the Illinois Department of Public Health has provided us with lists of art and craft materials which can be used in grades kindergarten through six. The lists of non-toxic art and craft materials, which are published annually, are expanded as more art and craft materials are evaluated. Refer to ISBE's List of Non-toxic Art and Craft Materials (1995) for products which can be purchased for use by students in grades kindergarten through twelve and to the P.A. 84-725 Toxic Art Supplies in Schools Act. (J.A. Spagnolo, personal communication, March, 1995)

The American Association for the Advancement of Science (AAAS) has recommended a major emphasis on themes in science curricula. Themes are the overarching ideas that integrate the concepts of different scientific disciplines, such as life science, earth science, and physical science. They also integrate the elements and principles of the visual arts and connect the concepts of science and art in meaningful ways. Many teachers are concerned about the management of materials and supplies during art and science lessons. Occasionally, such concerns actually prevent teachers from devoting as much time to art and science as they would like. Listed below are general safety guidelines when working with art materials in the classroom.

14.12.1 General Safety Guidelines

14.12.1.1 Safety

1. Use white glue or paste instead of resin-based glues and rubber cement.
2. Use acrylic paints rather than enamel or oil paints.
3. Use water-based printing inks rather than oil- or solvent-based inks.
4. Use water-based felt markers rather than solvent-based markers.
5. Have students wash their hands thoroughly with soap and water after art activities.
6. Check all art and craft materials for toxic substances.
7. Read and adhere to warning labels before using art or craft materials.
8. Especially in the primary grades, be sure students use only nonpointed scissors. If students must walk around carrying scissors, remind them to point the tips of the scissors toward the floor.
9. When working with chemicals, it is imperative that teachers understand the properties, hazards, and appropriate emergency procedures to follow in the event of an accident. *Material safety data sheets (MSDS) and the Merck Index provide this comprehensive information from chemical manufacturers, including physical property data, toxicity information, and handling and disposal specifications for chemicals.*

14.12.1.2 Set up

1. Cover desks and tables with newspaper. Students can fold odds and ends into the newspaper at cleanup time.
2. Before beginning any lesson, make sure that students understand cleanup procedures and know where to put finished work.

14.12.1.3 Cleanup

1. Collect brushes, pencils, or other implements as a first step in cleaning up. (This stops the art activity). One monitor can wash brushes later and stand them on their handles in a can to dry.
2. Avoid sink congestion by providing each student with one wet paper towel and one dry paper towel. These can be distributed loose or in a shallow tub. Have students wipe their hands with the wet towels and dry them with the dry towels, thus avoiding the sink altogether.

Refer to specific cleanup procedures outlined under the maintenance/use of various art materials (i.e. clay, tempera, etc.).

Below are general tips concerning the safety and use of specific art materials.

14.12.2 Tempera

1. When mixing powdered tempera, add several drops of dishwashing soap to the paint. This will cause the powdered paint to dissolve more quickly in the water. A few drops of dishwashing soap in liquid tempera will cause the paint to wash off hands more easily.
2. Arrange tempera paints in low containers such as cut-off milk cartons or margarine tubs with plastic lids. Arrange containers in shoe boxes for easy storage.
3. Collect a variety of plastic containers to use for water. Containers of different sizes can be stored inside each other.
4. Individual palettes for color mixing can be made of coffee can or margarine lids, plastic foam trays, and so on.
5. When mixing colors, show students how to rinse their brushes and dry them on paper towels so as not to muddy the paints.

14.12.3 Clay

1. Use one 25-pound sack of moist clay per class. Check the clay before the lesson to be sure it is still moist.
2. Use individual oilcloth place mats to cover desks. If oilcloth is not available, have students use masking tape to fasten fabric-backed wallpaper samples, heavy-duty aluminum sheets, or large flattened paper bags to their work surfaces.
3. Use a length of wire for cutting the clay.
4. Use plastic bags and rubber bands to store unused clay.
5. Provide each group of students with a tub or bucket to wash their hands, and a dry paper towel for each student.

14.12.4 Paste

1. Distribute paste on a small scrap of paper for each student.
2. When demonstrating collage, show students how to spread the paste on the back of the smaller piece of paper and then stick it to the larger piece.
3. Provide wet and dry paper towels for cleanup.

14.12.5 Watercolor

1. Demonstrate how to rinse the brush thoroughly with water when mixing colors, so as to avoid muddying colors.

2. Show students how to lightly dip the end of a facial tissue onto a wet watercolor pan to remove any muddy color.
3. When using crayon-resist techniques, note that some colors resist wax better than others. Different colors are made with different pigments. For instance, browns are heavier than other pigments and tend to lie on the crayon rather than resist it.
4. Old, dried-out watercolor pans should be discarded. After several years, the binding agent in the pigments deteriorates, and colors lose their luster.

14.12.6 Chalk

1. Reduce the amount of chalk dust produced when students use chalk. Before the activity, soak chalk pieces in water for one or two minutes, and then lay them on newspaper to dry. Using wet chalk will result in brighter colors and less dust, both in the air and on clothing.
2. Another way to reduce chalk dust is to have students dip their chalk into liquid starch before applying the chalk to paper. The starch will spread the chalk color over the paper without raising the dust. The same technique can be used with white liquid tempera paint on a colored construction paper background.

References

Illinois State Teachers Association. (1995). *List of Non-toxic Art and Craft Materials.* Springfield, IL: Author (pp. 88-93).
Tolley, K. (1994). *The Art and Science Connection; Hands-on Activities for Intermediate Students.* Menlo Park, CA: Addison-Wesley.

14.13 Field Trips

Field trips are a valuable, positive addition to the science program. A good field trip is a well planned trip, where educational objectives are identified and the activities conducted are intended to achieve those objectives. When the study in the field is well organized, the possibility of accidents occurring is greatly reduced. A few relatively simple precautions can ensure safety for all participants.

14.13.1 Field Trip Guidelines

1. Teachers should never take anything for granted where students are concerned and should always be alert for the unexpected.
2. If possible, a second responsible adult, known and approved by the school administration, should accompany the teacher on the trip.
3. Parent permission should be solicited and received before a student is allowed to go on a field trip.
4. Decide what to see, how long to spend in each place, and how long it takes to get from place to place.
5. First aid kits should be checked to see that they contain the essential first aid items.
6. Visit the site prior to the actual field trip. The teachers should have a thorough knowledge of the field trip area, including obvious dangers such as poisonous plants, snakes, water dangers, fall areas, and electrical hazards.
7. No trip should be taken to any body of water unless at least one person in the party is familiar with the latest methods of artificial respiration and with the rules of ordinary water safety as described in first aid handbooks, scouting manuals, and the American Red Cross Senior Life Saving.
8. Develop a list to be sent home identifying the proper clothing to be worn and the necessary equipment or supplies to be taken on the trip.

9. To prevent the risk of mite and tick infestation, plant poisoning, or scratches, students should wear clothing that covers the legs and arms.
10. Students taking trips near or into the water of a stream, river, lake or ocean should learn to recognize dangerous aquatic plants and animals common to the area.
11. When taking a field trip involving wading, the buddy system should always be used. Life jackets should also be available.
12. Trips to factories and laboratories must be well supervised and an experienced plant representative should conduct the tour.
13. Establish rules for safe conduct prior to taking the trip.
14. Glass collection jars or containers should be avoided. The use of plastic, paper, or cloth containers may prevent cuts and loss of specimens due to breakage.
15. Obtain up-to-date medical information and emergency telephone numbers for each student.
16. Establish clear physical boundaries and time limits.
17. Students should not put their hands into holes.

Refer to Chapter 15, The Outdoor Learning Area, for more information about safety and the outdoor classroom.

References

Biological Sciences Curriculum Study. (1992). *Science for Life and Living; Integrating Science, Technology, and Health.* Dubuque, IA: Kendall/Hunt (pp. T37, T38, & T40).
Martin, R., Sexton, C., Wagner, K., & Gerlovich, J. (1994). *Teaching Science for All Children.*
Needham Heights, MA: Allyn and Bacon (pp. 346-355).
National Science Teachers Association Subcommittee on Safety. (n.d.). Safety in the Elementary Science Classroom [Brochure]. Washington, D.C.: National Science Teachers Association (pp. 1-11).
North Carolina Department of Public Instruction. (1977). *Safety First in Science Teaching.* NC: Holt, Rinehart, & Winston (pp. 5-26).
North Carolina Department of Public Instruction. (n.d.). Elementary Science Safety Guide [Brochure]. NC: Author (pp.1-3).
Richardson, J., & Rolfe, G. (1981). *Field Activities in Ecology Education; A Guidebook for Elementary School Teachers.* Unpublished manuscript, University of Illinois at Urbana- Champaign (pp. 6-7).

Chapter 15
Outdoor Safety Standards
15.1 The Outdoor Learning Area

The outdoors is a valuable teaching tool and an incentive to learning. It presents many instructional opportunities that may not be possible within the regular classroom. It gives students the opportunity to have direct hands-on learning experiences in a natural setting and observe real-life phenomena. The outdoor learning area also presents safety considerations that are both similar and different from those that may exist in the regular classroom. The intent of this unit is to make teachers aware of those considerations, help them establish preventive techniques, and give them the knowledge to be prepared for safety situations that may arise.

15.1.1 Responsibilities

Though many of the responsibilities are similar to those in a regular classroom or laboratory, there are some additional responsibilities to be considered:

Administrative:

1. Provide an outdoor learning area that is safe for those who will be using it.
2. Require that routine inspections be performed daily before the site is to be used.
3. Establish an outdoor learning area safety committee and ensure that it meets regularly.

Teacher:

1. Discuss and establish a clear set of objectives for the students to accomplish during the outdoor learning area experience.
2. Provide a list of rules (see Sample Outdoor Learning Area Safety Rules) to the students and assess their understanding of those rules.
3. Develop a tool and equipment list and enforce the safe use of those tools. Always do an inventory at the end of equipment and tool use.
4. Review outdoor learning experiences before and after their implementation to determine their level of safety.
5. Be prepared for weather changes and make certain students are wearing the proper clothing at the time of the outdoor learning experience.
6. Make certain that each student has a role to play in the outdoor learning area experience. Small groups with specific assignments work best.
7. Establish a clear set of acceptable and unacceptable behaviors for students using the outdoor learning area.
8. Evaluate each outdoor experience to determine the need for additional supervisory persons.

Student:

1. Understand and abide by the safety rules established for the outdoor learning area.
2. Recognize that the outdoor learning area is for instructional purposes and it is not a recreational area.
3. Perform the activities always making safety a major consideration.
4. Report any activities to the teacher that may present safety risks.

Parents:

1. Review the outdoor learning area safety rules with your children.
2. Report any health conditions (allergies, asthma, etc.) that may make the outdoor learning area unsafe for your child.
3. Inform the administrator or teacher in advance of any conditions or situations where

you do not want your child to go out.
4. Sign and return the permission form if it is required.

15.1.2 Physical Layout of the Outdoor Learning Area

This is a very important consideration when taking students outdoors. It presents a very different challenge than a regular laboratory because you cannot lock the door behind you. However, what is learned about safety in the outdoor classroom becomes a carryover for students at home. It is very rare to have students who do not have the opportunity to explore the outdoors in their own backyards and neighborhoods. Understanding safety in the outdoors can go a long way to ensuring positive experiences for students and their parents as they explore the beauty and wonder of the natural world around them. Safety Audit and Safety Inspection (refer to chapter 3-1 for clarification). An example of an outdoor learning area safety audit is provided. This audit should be conducted at the beginning of the school year before the outdoor learning area is to be used. The routine safety inspection should be conducted before each daily use period. More detailed discussion of some of the items on the audit is provided later in this chapter.

Sample (Annual) Outdoor Learning Area Safety Audit

School: ____

Outdoor Learning Area Location: (Provide description or attach map of area.)

____

Teacher(s): ____

Grade level of students: ________ Type of use: ____________________________

Times of the year when in use ____

This list is to be used as a means of identifying certain desirable and undesirable features and structures, as well as hazardous conditions that may exist in the outdoor learning area. More specific details regarding these items can be obtained in this guidebook and in the references cited.

Outdoor Learning Area Layout Section in Guidebook

Yes No Comments

Is the area easily accessed?
Is there regular maintenance? 15.2.1
Is it handicapped accessible? 15.2.2
Is it close to the school building? 15.2.3
Have areas for concern been identified? 15.2.4

Policy and Procedures Section in Guidebook

Yes No Comments

Are there school or district policies requiring site inspections?
Refer to: Ch. 9.2
Are there requirements for reporting concerns?
Are all outdoor emergency procedures described in writing?
15.3.2
Have emergency procedures been practiced with students?
Have you received proper training for the appropriate emergency situations that could arise in the outdoors?
15.3.3
Is the first aid kit adequately stocked for the outdoor hazards that may exist?

15.3.4
Is there an emergency communication system available from the outdoor learning area (cell phone)?
15.3.5
Is the area free of hazardous waste? 15.3.6

Fixtures, Equipment and Structures Section in Guidebook
Yes No Comments

Are rules for equipment use, cleanup, and inspection established and available?
15.5.1
Are all pieces of equipment in proper working order or stored out of reach of the students?
Are outdoor human-made structures sound, safe, or protected?
15.5.2
Are all possible natural structures identified with consideration for safety hazards?
15.5.3
Is there an underground layout of water, gas and electricity lines?
15.5.4

Personal Protective Equipment and Clothing Yes No Comments

Are approved safety goggles available if conditions warrant the need?
6.4.1 &
15.6.1
Is there a means of sanitizing safety goggles between usage?
3.2.1 &
14.3.2
Are protective gloves available if conditions warrant the need?
6.4.2 &
15.6.2
Are there lab aprons available if conditions warrant the need?
6.2
Are hard-hats available if conditions warrant the need? 15.6.3
Are there general guidelines for dress in the outdoor learning area?
15.6.4

Outdoor Equipment/Tool and Chemical Storage Section in Guidebook
Yes No Comments

Is there a designated area for equipment/tool storage? 15.8.1
Is there adequate space for properly storing the equipment?
15.8.2
Are the chemicals kept in the proper facility? 7.5.1 & 15.8.3
Are protective leak-proof containers available for storing and transporting chemicals?
7.5.3 &
15.8.4
Are waste-chemical and waste-solvent containers transportable, capped and clearly labeled with their contents and the word "**WASTE**"? Are all containers of chemicals clearly labeled with the name of chemical, appropriate hazard warning, name of manufacturer or responsible party? Does the label on prepared solutions include the date mixed and the name of preparer?

7.5.6 &
15.8.5

Sample (Daily) Outdoor Learning Area Safety Inspection Form

School ______________________________

Outdoor Learning Area Site (garden, pond, prairie, etc.) _______________________

Inspector ____________________________

Date ________________________________

Check for site conditions: Satisfactory Unsatisfactory Date Remedied

Wetland area

Garden area

Pond area

Prairie area

Condition of: Satisfactory Unsatisfactory Date Remedied

Gardening equipment

Carpentry tools

First aid kit

Learning area lab equipment

Spill cleanup kits

Hazards Satisfactory Unsatisfactory Date Remedied

Natural and human-made obstructions are marked or clearly visible.

Restricted areas are posted and/or securely fenced.

Chemicals are properly marked and stored.

Site Maintenance Satisfactory Unsatisfactory Date Remedied

Trails

Tables and benches

Site structures (stream table, bird bath, etc.)

Litter removal

Hand rails and bridges

15.2 Outdoor Learning Area Layout

The layout of an outdoor learning area presents certain concerns that are different than those found in a classroom or laboratory. This area could simply be the school playground, or it could be an elaborate set of stations or areas set up for particular observations and/or experiments.

15.2.1 Regular Maintenance

An outdoor learning area, just like a regular classroom, requires routine maintenance to ensure a safe learning environment. The level of maintenance depends on the planned activities to be conducted within the area. An area that is to remain in its natural state and be used for observation purposes may require minimal maintenance. However, a site in which more varied activities will take place and learning stations will be constructed, will require a higher degree of upkeep. Routine maintenance might require such things as trail upkeep, pruning, station repairs, litter pickup, mowing, etc.

15.2.2 Handicap Access

The outdoor learning area should be accessible to students with disabilities. Be aware of potential safety hazards such as steep grades, wet areas, narrow trails, exposed tree roots, etc.

15.2.3 Proximity to the School Building

For safety concerns, it is important to be aware of the distance needed to travel in case of an emergency situation. It may be more important to have a first aid kit and cell phone and to pay closer attention to the weather and other elements when the outdoor learning area is located a reasonable distance from the building.

15.2.4 Areas of Concern

Certain places in an outdoor learning area may provide cause for additional concerns. Examples may include poison ivy, briars, stinging nettle, bee and hornet nests, natural structures, and human-made structures. These particular areas should be identified and the locations noted when performing the outdoor learning area audit.

15.3 Outdoor Learning Area Policy and Procedures

Many of the established emergency policies already associated with school use will pertain to the outdoor learning area. Some additional emergency concerns are addressed in the following sections.

15.3.1 Policies Requiring a Safety Committee and Site Inspections (Refer to 9.2)

15.3.2 Outdoor Emergency Procedures

Sections 4.1.4 - 4.2.4 provide information about laboratory emergency situations and offer examples of safety guidelines. An outdoor learning area safety policy and procedure should also include guidelines for animal stings and bites, physical injuries, bleeding, and exposure to the elements. The *Standard First Aid* book put out by the American Red Cross addresses all of the emergency situations listed above and should be part of the safety guidelines.

15.3.3 Outdoor Emergencies Training

To be prepared to deal with emergencies, teachers taking students into the outdoors should seek training from the school nurse and/or other qualified personnel. Once again, the American Red Cross provides a course in first aid as a way of preparing individuals to deal with all the emergency situations that may occur in the outdoor learning area.

15.3.4 First Aid Kit

A first aid kit should be well stocked and carried by the teacher into the outdoor learning area. It should be large enough so that the contents are readily visible and easy to access. Emergency medical forms may also need to be in the kit. To make refilling easy, a list of the contents should be maintained. Place a student in charge of taking the kit out and returning it to a convenient location.

Suggested first aid kit contents should include: 2-inch rolled bandage, 1-inch rolled bandage, 1-inch adhesive, 3-by-3-inch sterile gauze, triangular bandage, adhesive strips, scissors, tweezers, absorbent cotton, safety pins, needles, antiseptic towelettes, antiseptic ointment and spray, assorted sizes of band-aides, thermal blanket, activated charcoal, syrup of Ipecac and a cold pack.

To avoid exposure to communicable diseases when treating a bleeding victim, the first aid kit should also include latex gloves and goggles. To administer CPR, mouthpieces or mouth barrier devices should also be available. It is also a good idea to carry a container of water if it is not readily available at the site. Water is a universal need for washing eyes, skin, cuts, etc.

15.3.5 Emergency Communication

If the outdoor learning area is located some distance from the school, it may be wise to have a way to quickly communicate an emergency situation. A cell phone may be one way to address this concern. The need to place a 911 call and how it will be addressed in the outdoor learning area should also be considered. It may also be valuable to have a map of the area in the first aid kit to help give accurate directions to emergency response teams.

15.3.6 Hazardous Waste Site

It is assumed that any outdoor learning area on a school site is free of hazardous waste. However, if you are considering planting a garden, it is wise to contact the US Department of Agriculture or your local Soil and Water Conservation District to have your soil tested. This will provide other valuable planting information about your garden and establish a connection with these agencies.

15.4 Outdoor Learning Area Safety Rules for Students

Outdoor learning areas are normally very safe. To ensure your personal safety and the safety of others, you need to reduce the risks associated with the outdoors. By examining the possible risks, you will understand why the following rules have been developed for working in an outdoor learning area.

1. **Protect your eyes**. Appropriate eye protection must be worn at all times when using chemicals, testing water samples, or when working with tools or equipment that may cause flying debris. Chemical splash goggles provide maximum protection from splashes. Contact lenses should not normally be worn unless approved by your teacher. Unventilated goggles are essential if contact lenses are to be worn.
2. **Wear appropriate protective clothing**. Protective clothing such as long sleeved shirts, pants, and socks, can go a long way in preventing skin irritations from plants, chemicals, and insect bites. These clothes also keep you warmer in the fall and winter and are a barrier against sunburn in the spring and summer. Always pay close attention to the weather conditions when dressing for a day in the outdoor learning area.
3. **Wear shoes appropriate for the outdoors**. Sandals and open-toed shoes do not protect your feet. High heels and slip-on shoes are difficult to walk in and to keep on your feet when exploring the outdoors. High top tennis shoes or hiking/work boots are the best footwear.
4. **Do not taste any plants** that have not clearly been identified by your teacher as safe to eat. If you have had allergic reactions to certain foods, **do not** taste anything.
5. **Wash your hands with soap and cold water** after leaving the outdoor learning area. This procedure is advised in order to reduce the risk of skin irritation from poison ivy and the risk of micro-organism and bacterial infections.
6. **Know the hazards of the materials being used.** Read labels carefully to make sure you are using the right chemical. Know how to interpret data from a MSDS.
7. **Know the safety equipment**. Know the location of the first aid kit. Know how to respond in case of an emergency.
8. **Carry out only the experiments assigned by your teacher**. Never perform unauthorized experiments in the outdoor learning area.
9. **Never enter areas not designated** by your teacher as part of the learning experience.
10. **Never work in the outdoor learning area unless authorized to do so by your teacher**.

Never work alone. In case of a problem, you may need another person to prevent injury or even save your life.

11. **Never engage in horseplay, games, or pranks in the outdoor learning area.** Careless behavior can endanger yourself and others and it will not be tolerated. Remember that using the outdoor learning area is a privilege.

12. **Demonstrate safe behavior**. Obey all safety instructions given by your teacher and/or found in your experimental procedure. Before leaving the outdoor learning area make sure that the equipment is properly stored or secured for future users. Cleanup your work area.

13. **Dispose of all waste materials according to your teacher's instructions**.

14. **Report any accidents or unsafe conditions to your teacher immediately**.

15.5 Fixtures, Equipment and Structures

All equipment and structures must be carefully examined and considered for safety concerns. In the early stages of outdoor learning area development, some of the safety hazards may be eliminated just by making wise choices as to the location and the structures that will exist within the area. The types of sites that you wish to maintain will also dictate the equipment you may need.

15.5.1 Safety Rules for Outdoor Equipment Use

Outdoor equipment may include such items as manual garden and carpentry tools. **(Students should be prohibited from using any power tools and equipment.)** You should take into consideration the age, developmental level, skills and physical abilities of the students when deciding which equipment and tools they may use. Painting the equipment and tools a bright color will reduce the chance of injury and loss. Below are some safety rules that you can share with your students. Review the school's insurance policy to make certain there are no limitations to who may lift and move things.

Safety Rules for Equipment/Tool Use and Maintenance

It is important to use equipment and tools in a proper and safe manner. Many accidents can be avoided when you establish and follow policies for proper use and maintenance.

1. **Garden Tools** - When in use, garden tools such as rakes, hoes, and spades, should never be raised above waist level. When the tools are in the outdoor learning area and not in use, they should be set aside in a way that will avoid possible injuries. In other words, turn the sharp, pointed, and exposed edges of these tools down or away.
2. **Ladders** - Because of definite safety hazards, this equipment is off limits.
3. **Carpentry Tools** - Before you are given the opportunity to use these tools, you must demonstrate proficiency and safety with tools such as: hammers, saws, screwdrivers, etc.
4. **Outdoor Lab Equipment** - This equipment may require specific instructions and demonstration of proficiency before you are allowed to use it. Be sure that it is properly stored when not in use.
5. **Lifting and/or Moving Materials with or without Equipment** - When moving or lifting materials with or without equipment, proper instruction should be provided on how to accomplish such tasks. Never lift or move heavy materials without proper supervision and sufficient help.
6. **Maintenance** - All tools and equipment require a certain level of maintenance. After each use, you are responsible for cleaning the equipment/tools in a safe manner and inspecting them for possible damage. An example would be to check the head of a hoe or hammer to make sure it is not loose. Tool loss and bodily injury can also be reduced by painting the handles of your equipment a bright color.

15.5.2 Outdoor Human-Made Structures

Human-made structures in the outdoor learning area should be regularly checked to determine if they are safe. Remember that with certain structures, the natural weathering process causes deterioration. Possible structures of concern are:

15.5.2.1 Culverts - These structures are probably not places you will want to take your students and can be a safety hazard if not identified as off limits. However, if you decide that it provides a learning situation, be aware that it may have sharp edges and be a home for unexpected animals. Some students may also have a fear of this enclosed area.

15.5.2.2 Ponds - These areas, whether human-made or natural, require special safety considerations. It is wise to check with the insuring agent of the school district about safety requirements if a pond is being considered. To ensure safety, it is recommended that this area be fenced and posted with signs. Students should never be allowed in the area alone and unsupervised. Requiring young children to wear life jackets is a wise safety consideration. A flotation device with rope attached should be available for areas where the water could be over a student's head. Going into the water to save someone should only be attempted by a trained life guard. An observation site should be chosen, leaving the rest of the shoreline to remain in its natural state.

15.5.2.3 Buildings - Storage buildings should be kept locked when not in use. These and other buildings can be homes to nest-building insects and animals such as wasps, hornets, bees and mice.

15.5.2.4 Fences - Fences present several safety hazards that can be avoided if students are not permitted to climb on or over them.

15.5.2.5 Parking Lots - Parking lots may present obstacles when going to and from an outdoor learning area. Safety procedures should be established for crossing parking lots. In other words, students should cross as a group and stay out from between parked cars.

15.5.2.6 Roads - It is recommended that you do not take students to an outdoor learning area that is separated from the school by a road. However, if such a situation exists, a safety procedure should be established for crossing the road, including using a crossing guard, erecting road signs, and enforcing a crossing procedure.

15.5.2.7 Sewers - Storm sewers should be examined to make certain that they do not present a safety risk to students. Because they receive a large volume of water that creates unexpected forces, these areas should be avoided during or after a rain storm.

15.5.2.8 Drainage Ditches - A drainage ditch is normally designed to remove water quickly and take up as little space as possible. The sides are usually steep and sometimes slick. The water can be deep.

15.5.2.9 Compost Piles - Make sure that the enclosure presents no safety hazards such as sharp edges or loose wires. To avoid health problems, meats, dairy products, and fresh manure should not be placed in your compost piles. Avoiding these types of materials will reduce unpleasant odors and make the pile safe to handle.

15.5.2.9 Tables and Benches - These structures are often erected in the outdoor learning area and require routine maintenance. Natural weathering and vandalism can make what appears to be a sturdy structure a safety hazard.

15.5.3 Outdoor Natural Structures

15.5.3.1 Trees - Trees present several risks. Low hanging branches and dead or storm-damaged limbs should be removed or identified as possible safety concerns. Though tree climbing can be a favorite childhood experience, it may need to be prohibited in the outdoor learning area. Such an experience will require very specific safety guidelines

and may not be worth the liability risk.
15.5.3.2 Streams - Most Illinois streams run only intermittently and pose a low safety threat to student use. However, during and after rain storms many streams can become safety concerns. Stream currents are much more dangerous than one might expect. Water levels and current should always be checked before allowing students to come near or enter a stream. Always inspect the stream and stream bank area before use to remove unsafe litter that may have been washed in during heavy rains. If water is present in the stream, young students should never be left unsupervised. Slick rocks due to water, ice, and algae growth can also be a safety hazard. Students should be warned not to walk on wet rocks and not to do any rock hopping. It is advisable to mark gently sloping and uncluttered bank areas as observation and activity sites. This reduces the safety risks and leaves the rest of the stream bank as a natural area. A flotation device attached to a rope may also be safety consideration (see pond).
15.5.3.3 Bushes - Because bushes are low to the ground and can have needles and pointed tips, care should be taken when students are performing an activity nearby. Poisonous plants and briars also are frequently found growing beneath them. For this reason, students should never be permitted to crawl under them without proper supervision.
15.5.3.4 Ponds - (See 14.2.3)
15.5.3.5 Wetlands - A wetland area normally contains minimal levels of water, but it should be respected in the same ways as a pond or a stream. Water combined with saturated soil can present a safety risk to students.

15.5.4 Excavating the Outdoors

If you plan to do any digging in your outdoor learning area, be aware that underground utilities may exist and need to be mapped. You can obtain assistance in locating these utilities by contacting the Joint Utility Locating Information for Excavators (JULIE) (1-800-892-0123) in areas outside of the city limits of Chicago. Within the Chicago city limits, call DIGGER at 312- 744-7000. You must call at least 48 hours (excluding weekends and holidays) before you dig or initiate any activity that disturbs the earth.

15.6 Personal Protective Equipment and Clothing

Certain activities in the outdoor learning area may require personal protective equipment and clothing. Once again, the learning areas to be used and the types of activities to be performed will dictate the personal protective equipment and clothing needed**.**

15.6.1 Conditions That Warrant the Need for Safety Goggles

Certain situations where students are involved in chemical usage (see chapter 6.4.1), site construction, or site maintenance may require that students have eye protection. Closely evaluate each of these situations to determine whether eye protection is needed. Anytime students are working with chemicals that could cause eye irritation, goggles must be worn. Whenever students are working with tools or equipment that could create flying debris (hammers, chisels, sledges, etc.), goggles must be worn.

15.6.2 Conditions That Warrant the Need for Protective Gloves

For information about using gloves to handle chemicals, see section 6.4.2. In the outdoor learning area, gloves have several uses. They may be used to protect students' hands from poisonous plants, blisters, cold, sharp edges, abrasions, animal bites and infection. Once again, each situation will need to be evaluated to determine whether gloves should be required.

15.6.3 Conditions That Warrant Hard Hats

When students are performing activities or working in outdoor learning areas that contain overhead structures, it is advisable that they wear hardhats for protection. Hard hats can be obtained from local businesses or industry at little or no expense.

15.6.4 General Guidelines for Dress in the Outdoor Learning Area

Protective clothing, such as long sleeved shirts, long pants, and socks, can go a long way in preventing the side effects from irritating plants, insect bites, chemicals such as those found in fertilizers and concrete mix, and inclement weather. This type of protective clothing is also a barrier against ultraviolet radiation produced by the sun. Sunscreen and sunglasses may also be appropriate protective measures against ultraviolet radiation. Weather is always a determining factor when going to the outdoor learning area. By making sure that all students are properly dressed you will reduce the possibility of weather-related injuries such as frostbite and sunburn. Injuries from improper support and insect stings make sandals, high heels, slip-ons, and open-toed shoes inappropriate footwear for the outdoor learning area.

15.7 Chemical Use

Chemicals should be used minimally in the outdoor learning area. If they are used to control poison ivy or other noxious plants, it is recommended that this task be performed by adults. All other chemical use for experimental purposes should be closely monitored.

15.7.1 Chemical Handling

The rules for chemical handling are outlined in sections 7.1- 7.4 and are normally found on the container holding the chemicals. Never allow students to handle chemicals which you cannot properly identify.

15.7.2 Chemical Cleanup

The rules for proper cleanup of such tools as paint brushes and rollers are always listed on the side of the container. Equipment and tools used for making concrete and spreading fertilizers should be thoroughly washed to avoid rusting and to remove all skin irritants.

15.7.3 Chemical Disposal

Recommendations for proper disposal are also found on the side of containers with hazardous materials. Be sure to read sections 8.1 -8.2 for additional information on waste disposal.

15.8 Outdoor Equipment/Tool and Chemical Storage

Equipment and tools are especially common to any outdoor learning area. Having students participate in the construction and maintenance can be very rewarding and provide a sense of ownership and a concern for the aesthetic appearance of the site.

15.8.1 Designated Areas for Tool Storage

It is recommended that a tool/equipment storage area be built or identified. Equipment/tool storage in the classroom could produce safety hazards and be obstructions to walk areas and fire escape routes. The location of the storage site may determine who has accessibility to it.

15.8.2 Adequate Storage Space

Crowded and cluttered storage areas can create safety hazards. Consideration should be given to the amount of equipment/tools that can be properly stored within a given space.

15.8.3 Chemical Storage Facilities

When storing outdoor learning area chemicals such as fertilizers, pesticides, concrete mix, paints, and stains, the same rules should pertain to those followed in the laboratory storage of chemicals. Precautions should be taken to keep them under lock and key. The same rules found in section 7.5 should be followed. Be aware of the heat and freezing factors in an outdoor storage facility. A common mistake to avoid is leaving rags and brushes still containing combustible materials (paint, stain, etc.) laying around.

15.8.4 Containers for Storing and Transporting Chemicals

Once a fertilizer or concrete bag is opened, it is advisable to place the contents in a seal-proof storage container. Properly labeled five-gallon plastic buckets or heavy-duty trash cans with lids will work as proper storage containers for fertilizers and concrete. Paints, stains, and pesticides should already come in the proper containers. Care should be taken to seal the lids and store the containers in a way that will reduce the risk of spillage.

15.8.5 Labeling of Chemical Containers

Do not accept, use, or store any chemicals that are not properly marked. Refer to section 7.5.6 for additional information on chemical labeling.

15.9 Weather Conditions

Weather is always a determining factor when going to the outdoor learning area. By making sure that all students are properly dressed you will reduce the possibility of weather-related injuries such as frostbite and sunburn.

15.9.1 Determining Whether to Go Out or Not

Weather conditions for the day of the outdoor learning experience should be carefully monitored. If there is any indication that a major weather change is in the forecast, continuous weather and sky monitoring should go on throughout the day. The distance of the outdoor learning area from the school building becomes an important factor when a storm is in the forecast. Avoid extreme hot and cold conditions that may produce an unsafe or unpleasant learning experience.

15.9.2 Storm Warning Procedures

If there is even a slight bit of evidence that a storm is brewing, students should be directed to return to the building in an orderly fashion. Once inside, they should follow the normal storm warning procedures. Depending on the impending severity, tools and equipment may have to be left where they are. Lightning produces one of the most dangerous safety concerns. Students should always be directed to move away from trees and water and toward the shelter of the school. The best solution is to avoid going outdoors if storm alerts have been issued for your area. Always remind students to monitor the sky for possible weather changes.

15.9.3 Appropriate Weather Apparel

It is never a pleasant learning experience when your apparel does not fit the weather conditions. It can also become a safety hazard if students suffer from too much exposure to the heat or cold. Make certain that all of your students are properly dressed for the occasion. Remind students to inform you immediately if they are becoming too cold or too hot.

15.9.4 Appropriate Strategies for Activities for the Weather Conditions

It is important to make certain that the weather is suitable for the planned activities in the outdoor learning area. Activities that require a fair amount of exertion are not good for hot or cold conditions. Hot weather requires shaded areas and activities that can be done with little or no exertion. Cold weather requires sites protected from the wind and activities with just enough exertion to maintain needed body heat. Too much exertion can lead to sweating, an unsafe condition for cold weather. Establish a set of weather strategies to go by when choosing the outdoor learning activity. Remember that student comfort can have an impact on student safety.

15.10 Animals and Plants

Being able to properly handle and/or avoid certain plants and animals in an outdoor learning area is always a key safety concern. Rules should be established to help students understand safe and acceptable practices.

15.10.1 Invertebrate Animals

Invertebrate animals include protozoa, sponges, coelenterates, flatworms, roundworms, segmented worms, mollusks, arthropods (arachnids, crustaceans, centipedes, millipedes, and insects) and echinoderms. Those invertebrates that can cause serious safety concerns are listed below. Students should take care when handling any invertebrate animal so as not to injure them or get bitten in the process. Hands should always be thoroughly washed after handling animals to guarantee that no disease is passed on in the process.

15.10.1.1 Stinging Insects - Bees, wasps, bumble bees, hornets, and yellow jackets are the most common stinging insects. These insects do not go out and aggressively attack humans. Stings occur when they are surprised or aggravated and attack as a means of protection. Ground hornets and bumble bees can create the most problems because their nests are often overlooked. The outdoor learning area, especially places that are not mowed on a weekly basis, should always be carefully inspected for the nests of these insects. Knowing where they are and avoiding them will reduce the risk of stings.

NOTE: The school nurse should have and be trained to use an Epi-pen. This instrument can quickly deliver a shot of Epinephrine to a student who is having an allergic reaction to an insect sting.

15.10.1.2 Biting Insects - Mosquitoes, flies, ants, and chiggers are the most common biting insects. In the case of ants, care should be taken not to allow children to stand in areas where these insects may have their hills and colonies. Chiggers are most commonly found in grassy areas and seem to be most prevalent during the summer months. Mosquitoes and flies can present a problem at different times of the day and year. Repellents can be applied, but the directions for use on the container or in the American Red Cross *Standard First Aid* book should be carefully followed.

15.10.1.3 Arachnids - Spiders and ticks are the most common arachnids that may provide cause for concern. The only two spiders in Illinois whose bite can cause illness or death are the black widow and the brown recluse. Both of these spiders prefer dark and out-of-the-way places. It is advisable to have your students wear gloves when they are moving and/or reaching under or into rocks or brush. A student who is bitten by one of these spiders may not be aware of it until they begin to feel ill. Ticks present another problem in that they can be carriers of Lyme disease and Rocky Mountain spotted fever. Lyme disease is spread mainly by a deer tick. Because it can be as small as the head of a pin, many people overlook it. May to late August are the most common months for ticks. They are commonly found in wooded and grassy areas. The best way to avoid ticks is to wear long-sleeved shirts, tucked into long pants, that are tucked into your socks or boots. Wearing a hat, avoiding underbrush and tall grass, using a repellent, and checking yourself on a regular basis will reduce the risk of being bitten by a tick. Saving an embedded tick in a bag that can be sealed, may be helpful if tests need to be run.

15.10.2 Vertebrate Animals

Vertebrate animals include fish, amphibians, reptiles, birds, and mammals. Those vertebrates that can cause serious safety concerns are listed below. Students should take care when handling any vertebrate animal so as not to injure them or get bitten in the process. Gloves should be required when handling mammals. Hands should always be thoroughly washed after handling these animals to guarantee that no disease is passed on in the process.

15.10.2.1 Snakes - These animals kill fewer than 12 people a year in the United States. The northern half of Illinois is almost devoid of all poisonous snakes, while the southern half contains copperheads, rattlesnakes, and in the extreme south, cottonmouth water moccasins. It is also a known fact that more snake bites occur near the home than in the wild. To reduce the possibility of snakebites, avoid walking and/or reaching into areas that are not clearly visible, such as tall grass, rocks, logs, and brush.

15.10.2.2 Mammals - Mammals present a safety risk because their bite can cause injury, infection, and possibly result in rabies. Many wild mammals are active at night, so to see them during the day is a clear indication that they may be sick. Students should be carefully instructed not to catch or pet wild or even domesticated mammals in the outdoor learning area. Population studies of small rodents should only be performed by older students and under strict supervision of the teacher. Note: Studying insects such as grasshoppers, may be a safer way to do a population study.

15.10.2.3 Fish - Fish should be handled very carefully. Their fins can inflict punctures and cuts. Fish that are caught and released should not be handled with gloves. This can destroy the protective mucus that covers their scales and skin.

15.10.3 Plant Safety

Before using an outdoor learning area the site should be examined for the presence of poisonous plants. These plants should be removed from areas where students may come into contact with them. This can be a long and difficult process. Because students need the skill of being able to identify poisonous plants, it may be wise to leave some of these species where students can observe them without contact. Several poisonous plants, including poison ivy, are also a very important food for wildlife.

15.10.3.1 Poison Ivy - Poison ivy is fairly easy to identify because its compound leaves are divided into 3 leaflets that normally show a red color at the split. Berries are white and are found in clusters. Poison ivy can vary in size from low ground cover, to an erect shrub, to a hairy vine climbing up tree trunks. In the fall its red foliage is easy to spot. Poison ivy can be found in open woods, thickets, fence rows, roadsides, and waste areas. All parts of the plant contain an oil which causes an allergic reaction in some people. This can occur at any time of the year. The oil can be transferred to skin through direct contact with the plant or carried in smoke from burning plants. This oil can also remain on clothes and be transferred in that manner as well. Contrary to some beliefs, it is not possible to catch poison ivy from coming into contact with the rash. Students should be taught what poison ivy looks like and how to avoid contact with the plant. Wearing long pants and long sleeves should minimize the chances of contact. If, however, students do brush up against poison ivy, washing thoroughly with soap and cold water or dabbing alcohol on the affected area immediately after exposure will help remove the poisonous oil.

15.10.3.2 Poison Sumac - This plant also contains a skin irritant. Its compound leaves are made up of 7-13 pointed, smooth leaflets. Twigs are hairless. Berries are white and are found in clusters. Poison sumac varies in size from a tall shrub to a small tree. Because the plant is found in swamp or bog habitats, students in most of Illinois will have very little contact with it. Students should also avoid touching poison sumac, and follow the same procedures as for poison ivy if they have come into contact with the plant. NOTE: This plant should not be mistaken for the more common nonpoisonous sumacs that grow along the edge of wooded areas and have hairy twigs and/or toothed leaflets.

15.10.3.3 Poison Oak - The writers' sources indicate that poison oak is not found in Illinois.

15.10.3.4 Water Hemlock, Various Nightshades, Pokeweed (Pokeberry), Jimsonweed – These plants are poisonous if ingested. The problems with these types of poisonous plants can be avoided by simply making it *a rule that no one eats any wild plants found in the outdoor learning area*. Some wild plants are quite edible, but they should be identified by an expert before any student is given the opportunity to taste them. Strong emphasis should be placed on the fact that some wild plants are very poisonous and students should never eat any plant without being informed by an expert that it is safe to eat.

15.10.3.5 Mushrooms - Though they are not plants, several of these organisms are extremely poisonous if ingested. The above rules also apply.

15.10.3.6 Plants with Wind Carried Pollen - Teachers should always be aware that some students have allergies to pollen from various plants, including ragweed. It is advisable to avoid taking students with severe allergies outdoors on days when the pollen counts are high. In most cases, students with these allergies have been identified. If the teacher has any doubts, the school nurse should be contacted and/or the students should be asked if any of them suffer from allergies caused by pollen.

References

Conant, Roger. (1975). *A Field Guide to Reptiles and Amphibians of Eastern/Central North America*, Houghton Mifflin company, Boston.

Niering, William A. & Olmstead, Nancy C. (1979). *The Audubon Society Field Guide to North American Wildflowers*, Alfred A Knopf, Inc. New York.

Petrides, George A. (1972). *A Field Guide to Trees and Shrubs*, Houghton Mifflin Company, Boston.

Safety-Wise, Girl Scouts of the U.S.A. 420 Fifth Avenue, New York, N.Y. 10018-2702, Copyright 1993.

Standard First Aid, The American National Red Cross, Mosby - Year Book, Inc. 11830 Westline Industrial Drive, St. Louis, MO 63146, Copyright 1993.

Tyning, Thomas F. (1990). *A Guide to Amphibians and Reptiles*, Little, Brown, and Company, Boston.

Werner, William E. (1988). *Life and Lore of Illinois Wildflowers*, Illinois State Museum, Springfield, Illinois.

Appendix

Title 29 Code of Federal Regulations, Parts 1900-1926 - OSHA

1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories.

1.677 § 1910.1450 Occupational exposure to hazardous chemicals in laboratories.

* (Section 1910.1450 was added by 55 FR 3327, Jan. 31, 1990)

(a) Scope and application.

(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart 2, even if such use occurs in a laboratory.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) Definitions -

"Action level" means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

"Combustible liquid" means any liquid having a flashpoint at or above 100 deg. F (37.8 deg. C), but below 200 deg. F (93.3 deg. C), except any mixture having components with flashpoints of 200 deg. F (93.3 deg. C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means:

(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

"Designated area" means an area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, such as a laboratory hood.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"Employee" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i) "Aerosol, flammable" means an aerosol that,when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
(iv) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.
"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:
(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to forma a surface film under test; or
(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)).
Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.
"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.
Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and

determining whether or not a chemical is to be considered hazardous for purposes of this standard.

"Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

"Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safety manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"Medical consultation" means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence tat it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable

(reactive) or water-reactive.
"Protective laboratory practices and equipment" means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.
"Reproductive toxins" means chemicals which affect the reproductive chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).
"Select carcinogen" means any substance which meets one of the following criteria:
(i) It is regulated by OSHA as a carcinogen; or
(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or
(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or
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(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
(A) After inhalation exposure of 6 - 7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);
(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or
(C) After oral dosages of less than 50 mg/kg of body weight per day.
"Unstable (reactive)" means a chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.
"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.
(c) Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified
(d) Employee exposure determination
(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).
(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall

immediately comply with the exposure monitoring provisions of the relevant standard.
(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.
(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.
(e) Chemical hygiene plan - General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan.)
(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.
(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.
(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;
(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
(iii) A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
(iv) Provisions for employee information and training as prescribed in paragraph (f) of this section;
(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;
(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;
(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene

Committee; and
(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:
(A) Establishment of a designated area;
(B) Use of containment devices such as fume hoods or glove boxes;
(C) Procedures for safe removal of contaminated waste; and

(D) Decontamination procedures.
(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.
(f) Employee information and training.
(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.
(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.
(3) Information. Employees shall be informed of:
(i) The contents of this standard and its appendices which shall be made available to employees;
(ii) the location and availability of the employer's Chemical Hygiene Plan;
(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.
(4) Training.
(i) Employee training shall include:
(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
(B) The physical and health hazards of chemicals in the work area; and
(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective

equipment to be used.
(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) Medical consultation and medical examinations.
(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.
(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.
(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.
(3) Information provided to the physician. The employer shall provide the following information to the physician:
(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;
(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.
(4) Physician's written opinion.
(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:
(A) Any recommendation for further medical follow-up;
(B) The results of the medical examination and any associated tests;
(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of

exposure to a hazardous workplace; and

(D) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.
(h) Hazard identification.
(1) With respect to labels and material safety data sheets:
(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.
(2) The following provisions shall apply to chemical substances developed in the laboratory:
(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.
(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.
(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.120) including the requirements for preparation of material safety data sheets and labeling.
(i) Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) Recordkeeping.
(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.
(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.
(k) Dates
(1) Effective date. This section shall become effective May 1, 1990.
(2) Start-up dates.
(i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.
(ii) Paragraph(a)(2) of this section shall not take effect until the

employer has developed and implemented a written Chemical Hygiene Plan.
(l) Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

Title 29 Code of Federal Regulations, Parts 1900-1926 - OSHA
Appendix A to _ 1910.1450 - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

Table of Contents

4. Chemicals of High Chronic Toxicity
5. Animal Work with Chemicals of High Chronic Toxicity
F. Safety Recommendations
G. Material Safety Data Sheets

Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted form "Prudent Practices" for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW,. Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards.

Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical Hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	Relevant appendix section
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures	

D
(e)(3)(iii) Fume hood performance C4b
(e)(3)(iv) Employee information and training
(including emergency procedures).
D10, D9
(e)(3)(v) Requirements for prior approval of
laboratory activities.
E2b, E4b
(e)(3)(vi) Medical consultation and medical
examinations.
D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities. B
(e)(3)(viii) Special precautions for work with
particularly hazardous substances.
E2, E3, E4

In this appendix,those recommendations directed primarily at administrators and supervisors are given in sections A - D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).
2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).
3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).
4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).
5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental

Industrial Hygienists should not be exceeded (13).
B. Chemical Hygiene Responsibilities
Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:
1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).
2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).
3. chemical hygiene officer(s), whose appointment is essential (7) and who must:
(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);
(b) Monitor procurement, use, and disposal of chemicals used in the lab (8);
(c) See that appropriate audits are maintained (8);
(d) Help project directors develop precautions and adequate facilities (10);
(e) Know the current legal requirements concerning regulated substance (50); and
(f) Seek ways to improve the chemical hygiene program (8, 11).

4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:
(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);
(b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);
(c) Know the current legal requirements concerning regulated substances (50, 231);
(d) Determine the required levels of protective apparel and equipment (156, 160, 162); and
(e) Ensure that facilities and training for use of any material being ordered are adequate (215).
5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).
6. Laboratory worker, who is responsible for:
(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and
(b) Developing good personal chemical hygiene habits (22).
C. The Laboratory Facility
1. Design. The laboratory facility should have:
(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

(b) Adequate, well-ventilated stockrooms/storerooms (218, 219).
(c) Laboratory hoods and sinks (12, 162);
(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and
(e) Arrangements for waste disposal (12, 240).
2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).

3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).
4. Ventilation - (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).
(b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.
(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).
(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).
(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).
(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).
(g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate

(typically 60-100 lfm) (200, 204).
(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below)

2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19). Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should

be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

(b) An easily accessible drench-type safety shower (162, 169);

(c) An eyewash fountain (162)

(d) A fire extinguisher (162-164);

(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits

(27) and areas where food and beverage consumption and storage are permitted (24); and
(d) Warnings at areas or equipment where special or unusual hazards exist (27).
9. Spills and Accidents
(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).
(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).
(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).
(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).
10. Information and Training Program
(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).
(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).
Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).
Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.
(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).
(d) Frequency of Training: The training and education program should be a regular, continuing activity - not simply an annual presentation (15).
(e) Literature/Consultation: Literature and consulting advice concerning

chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).
11. Waste Disposal Program.
(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).
(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).
(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).
Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage

(226).
(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).
(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).
Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).
Hoods should not be used as a means of disposal for volatile chemicals (40, 200).
Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.
E. Basic Rules and Procedures for Working with Chemicals
The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.
1. General Rules
The following should be used for essentially all laboratory work with chemicals:
(a) Accidents and spills - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).
Ingestion: Encourage the victim to drink large amounts of water (178).

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).
Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.
(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);
Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).
Inspect gloves (157) and test glove boxes (208) before use.
Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).
(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).
(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).
Avoid storage, handling, or consumption of food or beverages in storage

areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).
(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).
(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).
(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).
(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).
(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).
(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).
Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).
Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).
Use any other protective and emergency apparel and equipment as appropriate (22, 157-162).
Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).
Remove laboratory coats immediately on significant contamination (161).
(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).
(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).
(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).
As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50

ppm (13).
Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).
Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).
(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).
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(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).
Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).
Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).
(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).
2. Working with Allergens and Embryotoxins
(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).
(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.
Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.
Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.
Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.
3. Work with Chemicals of Moderate Chronic or High Acute Toxicity
Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).
Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):
(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions
(39).
(b) Applicability: These precautions are appropriate for substances with

moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to revent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure

or under laminar air flow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6) 2. Electrically powered laboratory apparatus: (179-92) 3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7) 4. Low temperature procedures: (26, 88) 5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

G. Material Safety Data Sheets

Material safety data sheets are presented in "Prudent Practices" for the chemicals listed below. (Asterisks denote that comprehensive material safety data sheets are provided).

*Acetyl peroxide (105)
*Acrolein (106)
*Acrylonitrile
Ammonia (anhydrous)(91)
*Aniline (109)
*Benzene (110)
*Benzo[a]pyrene (112)
*Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
*Tert-butyl hydroperoxide (148)
*Carbon disulfide (116)
Carbon monoxide (92)

*Carbon tetrachloride (118)
*Chlorine (119)
Chlorine trifluoride (94)
*Chloroform (121)

Chloromethane (93)
*Diethyl ether (122)
Diisopropyl fluorophosphate (41)
*Dimethylformamide (123)
*Dimethyl sulfate (125)
*Dioxane (126)
*Ethylene dibromide (128)
*Fluorine (95)
*Formaldehyde (130)
*Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
*Hydrogen cyanide (133)
*Hydrogen sulfide (135)
Mercury and compounds (52)
*Methanol (137)
*Morpholine (138)
*Nickel carbonyl (99)
*Nitrobenzene (139)
Nitrogen dioxide (100)
N-nitrosodiethylamine (54)
*Peracetic acid (141)
*Phenol (142)
*Phosgene (143)
*Pyridine (144)
*Sodium azide (145)
*Sodium cyanide (147)
Sulfur dioxide (101)
*Trichloroethylene (149)
*Vinyl chloride (150)
Appendix -29

Title 29 Code of Federal Regulations, Parts 1900-1926 - OSHA
Appendix B to _ 1910.1450 - References (Non-Mandatory)

The following references are provided to assist the employer in the development of a Chemical Hygiene Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory. (a) Materials for the development of the Chemical Hygiene Plan:

1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.
2. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley-Interscience, New York, 1982.
3. Flury, Patricia A., Environmental Health and Safety in the Hospital

Laboratory, Charles C. Thomas Publisher, Springfield IL, 1978.
4. Green, Michael E. and Turk, Amos, Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.
5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, MI 48640, 1977.
6. National Institutes of Health, NIH Guidelines for the Laboratory use of Chemical Carcinogens, NIH Pub. No. 81-2385, GPO, Washington, DC 20402, 1981.
7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC, 1983.
8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.
9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol. IV, J. Chem. Ed., American Chemical Society, Easlon, PA, 1981.
10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, J. Chem. Ed. American Chemical Society, Easlon, PA, 18042, Vol.I, 1967, Vol. II, 1971, Vol. III, 1974.
11. Steere, Norman V., Handbook of Laboratory Safety, the Chemical Rubber Company Cleveland, OH, 1971.
12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:
1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438 (latest edition).
2. Annual Report on Carcinogens, National Toxicology Program U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC, (latest edition).
3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, N.J., 1981.
4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.
5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.
6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S. Govt. Printing Office, Washington, DC 20402 (latest edition).
7. IARC Monographs on the Evaluation of the Carcinogenic Risk of chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).
8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85-114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).
9. Occupational Health Guidelines, NIOSH/OSHA. NIOSH Pub. No. 81-123 U.S. Government Printing Office, Washington, DC, 1981.
10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons,

Inc., New York, NY (Five Volumes).
11. Registry of Toxic Effects of Chemical Substances, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Revised Annually, for sale from Superintendent of documents US. Govt. Printing Office, Washington, DC 20402.
12. The Merck Index: An Encyclopedia of Chemicals and Drugs. Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).
13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY., 1979.
14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications. Park Ridge, NJ, 1981.
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(c) Information on Ventilation:
1. American Conference of Governmental Industrial Hygienists Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438.
2. American National Standards Institute, Inc. American National Standards Fundamentals Governing the Design and Operation of Local Exhaust Systems ANSI Z 9.2-1979 American National Standards Institute, N.Y. 1979.
3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety pp 15-18, April 1980.
4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA-45, 1982.
Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980.
Fire Protection Guide on Hazardous Materials, 7th edition, 1978.
National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.
5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW., Washington, DC 20036.
(d) Information on Availability of Referenced Material:
1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.
2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.
(Approved by the Office of Management and Budget under control number 1218-0131)
* [55 FR 3327, Jan. 31, 1990]

Glossary
ACGIH American Conference of Government Industrial Hygienists
ACS American Chemical Society
ANSI American National Standards Institute
CFR Code of Federal Regulations
CFR Code of Federal Regulations
CHEMIS Chemical Health and Environmental Management in Schools
CWA Clean Water Act
DOT United States Department of Transportation
EPA Environmental Protection Agency
ILCS Illinois Compiled Statutes
MSDS material safety data sheet
NFPA National Fire Protection Association
NIOSH National Institute for Occupational Safety and Health
NSTA National Science Teachers Association
OSHA Occupational Safety and Health Administration
PEL permissible exposure limit
PPE personal protective equipment
RICRA Resource Conservation and Reauthorization Act
SARA Superfund Amendments and Reauthorization Act
TLV threshold limit value
TOSCA Toxic Substances Control Act
UL Underwriters Laboratory
UV ultraviolet