- NEVER leave an open flame unattended. When a burner is not in use, turn it off.
- Do NOT reach across an open flame.
- Light bulbs used in experiments should be the lowest wattage possible.

## Heating Objects/Substances

- Always wear goggles when heating substances in the lab. Where possible, heat substances in a fume hood.
- Use a hot plate, rather than a gas burner, when evaporating liquids.
- Objects should NOT be held in a gas-burner flame for an excessive period of time.
- Always point the open end of a test tube away from yourself and others. **WARNING:** *Some chemicals can boil out of the test tube violently and unexpectedly when they are heated.*
- Heat-generating chemicals should be mixed slowly.
- NEVER heat chemicals in a closed container such as a corked test tube. **WARNING:** *The expanding gas inside will cause the test tube to explode or turn the stopper into a projectile with considerable force.*
- Do NOT use bare hands to pick up a container that has been heated or hand a heated container to someone. Hold the back of your hand near the container and check for heat before handling. If you can feel heat, use a mitten or tongs to pick up the container.
- NEVER reach across a hot apparatus to perform an experiment. The apparatus should be placed so that if hot liquids are spilled, they will fall onto the laboratory table, not onto a person.
- Watch heated objects constantly, and shield them from accidental contact.
- Limit air flow from open doors and windows when working with flammables.Limit the quantity of flammable and combustible chemicals in the work area to the amount actually necessary to complete the task at hand. For example, do NOT leave the can of alcohol nearby after you fill the alcohol burners.

## Using Electrical Apparatuses

- Make sure that all electrical cords are in good condition and are not frayed or cracked. **WARNING:** *Do NOT use any electrical equipment that needs repair.*
- Make sure that circuits are not overloaded.
- Turn off all power sources when you set up circuits or repair equipment.
- Check all circuits set up by students before the power is turned on.
- When you assemble circuits, connect the live portion last. When you disassemble them, disconnect the live portion first.
- Do NOT use or wear metal articles, such as rulers, metal pencils or writing pens, or jewelry when working with electrical equipment.

- When disconnecting electrical equipment, pull from the plug and not from the cord.
- Use caution when handling electrical equipment that has been in use. The equipment might be warm or hot from being used.
- Keep electrical equipment away from water.
- NEVER connect, disconnect, or operate a piece of electrical equipment with wet hands or while standing on a wet floor.
- Use precautions to prevent spills on electric equipment or electrical outlets.

## Working with Chemicals

- Read labels twice before using any chemical.
- Work carefully with oxidizing agents. **WARNING:** *Chlorates, nitrates, or peroxides and other oxidizers should NOT come into contact with combustible substances.*
- Discard any glove with holes or cracks. **WARNING:** *Some chemicals can diffuse through a glove, increasing exposure when the glove holds the chemical against the skin.*
- When removing gloves, peel the gloves off your hand, starting at the wrists and working toward the fingers. Keep the outside surface of the gloves from touching the skin during removal.
- Match the correct glove to the substance you are going to use. Refer to the labels on the glove boxes. **WARNING:** *Some kinds of gloves can dissolve when they are in contact with a solvent.*
- Use extra precaution with acids and bases. **WARNING:** *Always pour acid into water. Do NOT pour water into acids.*
- Wash an acid or base from your skin immediately.
- Use a pipette bulb. NEVER pipette liquids using your mouth.
- Do NOT pour extra chemicals back into the original containers. This causes contamination of the chemicals and can produce incorrect results in future investigations.
- NEVER use the same spatula to remove chemicals from two different containers. Each container should have its own spatula.
- When removing a stopper from a bottle, do NOT lay it down on the lab table, but place the stopper between two fingers and hold the bottle so that the label is in the palm of your hand. Both the bottle and the stopper will be held in one hand.
- Replace all stoppers and caps on the correct bottles as soon as you have finished using them.
- Do NOT model a volcano using ammonium dichromate.
  **WARNING:** *Ammonium dichromate produces chromium(III) oxide, a carcinogen.*

## Working with Minerals

- Avoid identifying minerals by tasting. **WARNING:** *Tasting any substance is NOT recommended. Even if the substance is safe, the container might not be. Some semimetals, such as arsenic, antimony, and allemontite, are poisonous.*

- In the event that you work with uranium ores, minimize risks by using the smallest sample for the shortest amount of time possible. **WARNING:** *Avoid direct contact with the ore—use tongs or forceps and sealed samples.*

## Using Thermometers

- NEVER use a mercury thermometer.
- NEVER hold the thermometer bulb in an open flame.
- Wrap a strip of tape around thermometers. Leave a protruding piece to keep the thermometers from rolling off work surfaces.

## Using Batteries

- Check batteries to be sure they are charged and not leaking. Properly dispose of all leaking batteries.
- Clean with soap and water all places a leaking battery has contaminated.
- **WARNING:** *Do NOT try to recharge any battery not specifically designed to be recharged. An explosion can result.*
- **WARNING:** *Do NOT try to heat a battery to make it work better. It might explode.*
- **WARNING:** *Do NOT store loose batteries in drawers where they can roll around. The rolling action could cause the batteries to leak.*

## Using Lasers

- The laser beam should be at waist-level or below whenever possible.
- Use laser goggles and disinfect them after use.
- NEVER point the laser at anyone.
- NEVER stare at the laser beam or view the reflected beams.
- Block off the beam past the target. (A sheet of rough wood or a flat piece of carbon available at industrial lighting stores works well.) The target and any objects in the beam area should be nonreflective.
- NEVER leave the laser unattended. Prevent unauthorized access.
- Be sure the laser cord is grounded.
- Set up prisms and mirrors in advance to avoid unexpected reflections when you use a laser. Avoid other accidental reflections when using a laser by removing jewelry, wall mirrors, and other reflective surfaces.

## Using Centrifuges

- Make sure the centrifuge is securely anchored in a place where its vibrations will not cause bottles or equipment to fall.
- Always close the centrifuge lid during use.
- Do NOT walk away from a running centrifuge until full operating speed is reached and the machine is running smoothly without excess vibration.

- Immediately stop the centrifuge if it starts to vibrate. Check that tubes are loaded symmetrically and contain approximately the same amounts of liquid.
- Regularly clean the buckets, centrifuge tube cushions, and rotors. **WARNING:** *Glass shards or other substances in the cushions are a common cause of tube breakage.*
- Do NOT touch a centrifuge while it is spinning.

## Using Glassware

- **WARNING:** *Glass cools slowly. Do NOT touch glass that has been heated unless you have allowed sufficient time for cooling. Hold your hand over the glass to feel for heat emanating from it before touching. Always place hot glass on a heat-proof pad, never on a metal or a wooden desktop.*
- Heat and cool glass slowly. Do NOT set a hot beaker on a cold or damp surface, as this can cause the beaker to crack or shatter.
- When heating glassware, use a wire or ceramic screen to protect the glassware from the flame.
- NEVER use glassware that is scratched or chipped—failure and breakage can result.
- Wrap or strip glassware with masking tape if it is to be used under vacuum or pressure. This will prevent flying pieces of glass in the event of an implosion or explosion.
- Reduce scratches in glassware by using rubber-tipped stirring rods and coated clamps and by cleaning glassware immediately after use.
- NEVER eat or drink from laboratory glassware.
- NEVER heat pipettes, volumetric flasks, or burettes; they can change volume as a result of expansion.
- Clean glassware thoroughly before you store it.

## Working with Glass Tubing

- Always protect your hands with several layers of cloth when you insert glass tubing into or remove it from rubber stoppers.
- Lubricate glass tubing or thermometers with glycerin, water, or stopcock grease before you insert them into a rubber stopper. Use a turning motion on the glass tubing when you insert it into a rubber stopper or rubber tubing.
- Remove glass tubing or thermometers from rubber stoppers as soon as possible in order to prevent the rubber or cork from adhering to the glass. If the tubing or thermometer does stick to the stopper, only a teacher should attempt to separate the two. The teacher should wear gloves and goggles, and may be able to release the frozen area by running a stream of hot water over it. Using a strip of paper between ground joints, frequently lubricating stopcocks, or taking apart the equipment for storage will help limit the problem. It is advisable to cut the rubber stopper when a thermometer is involved to avoid breaking the thermometer.

- Commercially made glass-tube cutters work well for cutting tubing. Wear safety goggles and protective gloves when cutting glass.
- After cutting glass tubing, always fire-polish the ends to remove any sharp edges. When bending glass tubing or fire-polishing cut-glass tubing, NEVER hand the hot end of the tubing to anyone until it has cooled.

## Using Fume Hoods

- Work as far inside the hood as possible, at least 16 cm from the front edge.
- Work with the sash in the lowest position possible. NEVER work with the sash higher than chin level. The sash must be low enough to protect the head and upper body in case of an explosion.
- Even though the sash to the fume hood separates your face from the apparatus and materials under the hood, you also MUST use the personal safety equipment required for the activity.
- The sash must be kept in place except when setting up an activity. Do NOT conduct the activity until the sash has been returned to its proper safe position.
- Close the sash when the hood exhaust system is not operating.
- While preparing to use or while using the fume hood, keep the interior light on so that the working area has proper illumination.
- Place blocks under large objects so that there is proper air flow under the objects.
- NEVER store chemicals or materials in the hood.
- NEVER place electrical apparatuses or items that can produce a spark in the fume hood.

## Using Electron Beams

- Cathode ray tubes and microwave tubes should be used with extreme care—operated at the lowest possible current and voltage with the operating time kept to a minimum. It is recommended that these tubes be used only by the teacher for demonstrations and that the students stand at least 2.5 m away from the tubes when they are in use. **WARNING:** *These tubes can produce X-rays.* **WARNING:** *The glass in any vacuum tube becomes brittle with age and can implode.*
- Infrared/ultraviolet goggles or an approved welders' face shield should be worn when these light rays are used. **WARNING:** *Infrared radiation and ultraviolet rays damage the eyes.*
- Eye protection is required for protection from mercury light sources. **WARNING:** *Mercury light sources can emit ultraviolet rays.*
- Using the Sun as a light source for lenses and prisms is NOT recommended. **WARNING:** *There is NO safe way to look directly at the Sun.*

## Working with Biological Samples

- Consider substituting films, videos, and computer simulations for dissection activities.
- Carefully remove specimens from preservative solutions. Wear gloves and use tongs or forceps. **WARNING:** *Formalin solutions are carcinogenic. Any specimen kept in a formalin solution should be soaked in a water bath in a fume hood and then thoroughly rinsed in running water for several minutes. Preferably, these specimens should be replaced with ones stored in safer solutions.*
- When placing a blade onto a scalpel, leave the blade in the original package and hold the blade securely with the cutting edge away from your fingers. To remove the blade, use tweezers or forceps and always push the blade away from your body.
- During dissection, do NOT hold the specimen in your hand. Cut down into the specimen, NOT up toward your body.
- Most insects can be anesthetized by freezing them in a jar for up to an hour.
- Most insects may be killed by placing them in an airtight container in a freezer for 48 hours.
- Do not perform investigations with syringes with needles.

## International System of Units (SI)

Emphasize to students why it is necessary to use compatible units when carrying out investigations. Explain that not only should all units of measure be in SI units, but also that all of the measurements used in an equation should be in the same units. For example, if some units of measurement in a relationship are in millimeters and some in centimeters, you must convert the amounts in centimeters to millimeters or the amounts in millimeters to centimeters.

## Assessing Students' Readiness for Lab Tasks

Before students begin work on assigned investigations, foster a climate of safety and proper equipment use by assessing the knowledge and proficiency of the skills required. This is especially important for students new to the science laboratory or who are new to your school.

You might wish to set up various stations in the classroom, having a small group of students demonstrate their skills in performing certain tasks and using the appropriate devices at each station. For example, have students observe plant cells with a microscope. You should watch to see that they focus the lens and handle the microscope and sample properly. Rotate the groups through the stations until you have assessed the skills of each student. Rate each student's performance and provide additional instruction to those students who need it.

# Maintain an Environmentally Safe Laboratory

## Waste Disposal Guidelines

This section deals with daily cleanup needs and temporary storage of waste products.

Work with your custodial department to develop safe ways to store wastes. Identify a safe place to store waste after it leaves the classroom laboratory. Keep school administration and local officials, such as the fire department, informed about the location of waste stored temporarily and your waste disposal procedures.
**WARNING:** *Most states place a limit on the volume of chemicals that can be stored in school facilities. Know your state and local regulations regarding safe chemical storage.*

Use separate containers for different kinds of waste—paper, trash, broken glass, biohazardous materials, sharp objects contaminated with biohazardous fluids, toxic or caustic waste, and so on. **WARNING:** *Waste that contains both safe and hazardous substances is considered hazardous waste*. Equipment supply companies sell proper waste containers. Make sure the containers have the proper labels with safety icons and that students recognize the labels. **WARNING***: Do NOT stack the containers; leaks must be visible to ensure prompt corrective action.*

### Broken Glassware

Clean up broken glassware immediately. Set aside gloves, a brush, and a dustpan for that purpose. Wet cotton balls are effective for picking up tiny pieces of glass.

### Batteries

Batteries can contain caustic substances and should be kept separate from other types of trash. **WARNING:** *Do NOT incinerate batteries. They are explosive*. Some newer types of batteries must be recycled in some communities. Find out about recycling regulations in your area.

### Other Chemicals

Some chemicals can be washed down the sink. For example, almost all sodium compounds can be washed down the drain. Refer to water treatment officials for guidelines—they probably recommend that all liquid waste be adjusted to a pH between 5 and 8.

Any waste that must not be washed down the drain should be kept in safe containers. Empty reagent bottles with a plastic coating are suitable for most liquid waste. Solid waste can be discarded in empty chemical jars. Only similar, compatible wastes should be collected in a single container. **WARNING:** *All stored waste MUST be labeled. Waste disposal costs rise for unknown substances. Unknown substances may NOT be disposed of in the water or land.*

### Biological Contamination

Place biological specimens and bandages, towels, and gloves used in cleaning up blood and other bodily fluids in the red biohazard containers and dispose of properly. Place sharp items such as needles and scalpel blades in a red biohazard container made especially for sharp objects. Glassware and glass microscope slides can be sterilized and reused.

## Sterilization Procedures

Clean glassware is necessary to keep from contaminating an experiment and to provide safe equipment for students to use. Clean eyewear after each use.

### Goggles

Germicidal ultraviolet (UV) cabinets are available for sterilizations. If used, follow the manufacturer's instructions. Check the UV intensity yearly with a UV meter. Clean the lamp often (weekly), as dust and dirt affects the intensity of the lamp. One drawback to the UV cabinet is the time it takes for sterilization to occur. The following alternative method may be used if a UV cabinet is unavailable or inconvenient to use.

1. Clean the goggles, frame, and lenses with liquid detergent on a paper towel. Rinse the goggles with water and partially dry with a paper towel. Use a separate paper towel for each pair of goggles.
2. Dip the goggles into a solution of one tablespoon of household bleach and one quart of water or wipe the goggles with a gauze pad or cotton ball soaked with a 70 percent isopropyl alcohol solution. Note: Make the bleach solution fresh daily.
3. Let the goggles air-dry.
4. In case of an infection, the goggles should be soaked in the bleach solution for 10 minutes following washing with a liquid detergent. This bleach solution should be used only for one pair of goggles and discarded immediately afterward.

### Glassware

Glassware should be washed immediately. If immediate washing is not possible, soak the glassware until it can be washed. Most glassware can be cleaned with detergents and brushes. The glassware should be washed thoroughly with detergent and rinsed several times, with a final rinse of distilled water. (If all the detergent is not removed with the rinsing, the detergent will react with acids to form a grease coating on the glassware.) **WARNING:** *Do NOT use worn brushes with exposed metal that can scratch the glass.*

Various methods may be used to sterilize glassware.

- *Dry heat.* Larger pieces of heat-resistant glassware (petri dishes, beakers, graduated cylinders, test tubes) can be sterilized by placing them in an oven at a temperature of 350°F for 2 h. Glassware should be loosely wrapped in aluminum foil and placed on a metal tray or cookie sheet. Put them in a cold oven and turn on the heat to reach a setting of 350°F. Leave the glassware in the oven for two hours after it has reached the proper temperature. After this time, the glassware can be removed from the oven. Remember to use heat-proof gloves to remove the tray and place it on a heat-proof surface to cool.
- *Steam under pressure*. Place media or glassware in a pressure cooker or autoclave for 15 minutes. **WARNING:** *Do NOT open the cover until you turn off the heat source and allow the pressure to return to normal.*
- *Boiling*. Smaller pieces of glassware (droppers, stirring rods, and so forth) can be sterilized by boiling them in water for 30 minutes.
- *Using chemicals*. Culture dishes can be soaked in a 10 percent solution of household bleach and then rinsed with water, finishing with a rinse with distilled water. **WARNING:** *Wear rubber gloves to avoid burns when using strong disinfectants*. **WARNING:** *Some residues are not affected by detergents*. Discard glassware that cannot be properly cleaned. In many cases, plastic one-time use materials can be used. Petri dishes, for example, are available in plastic forms. If contaminated with a harmful organism or substance, even plastic Petri dishes must be sterilized before they are discarded.

# Manage Laboratory Materials Storage

It is your responsibility to be informed of the local, state, federal, and district/school rules that govern the storage and disposal of materials used in your classroom/laboratory. This section discusses Material Safety Data Sheets, storage factors such as the nature of hazardous materials and chemical incompatibility, storage and handling procedures, inventory practices, and waste disposal.

## Material Safety Data Sheets (MSDS)

You should keep an MSDS file for all the chemicals you use and store in your classroom/laboratory. Manufacturers provide MSDS for each chemical they produce. An MSDS includes the following information:

- the name of the chemical
- manufacturer's name and address
- physical and health hazards, including organs it would affect
- first aid measures
- CAS number assigned by the Chemical Abstract Service
- chemical formula
- molecular weight for compounds, the atomic weight for elements
- common name of the chemical
- purity of the substance
- lot numbers
- supplier's name and address

See a sample MSDS. Note that the sample is for a solution of sodium chloride (table salt), a common substance not considered hazardous. Even so, there are several safety issues concerning this table salt solution (indicated by the highlighted portions of the MSDS).

**MATERIAL SAFETY DATA SHEET**

**Sodium Chloride 25%**
90175

**SECTION 1—CHEMICAL PRODUCT AND COMPANY IDENTIFICATION**

*MSDS Name:* Sodium Chloride 25%
*Catalog Numbers:* 99150
*Synonyms:* None
*Company Identification:* [Manufacturer's name and address go here]
*For information, call:* [Manufacturer's phone numbers]
*Emergency Number:*
For CHEMTREC assistance, call:
For International CHEMTREC assistance, call:

**SECTION 2—COMPOSITION, INFORMATION ON INGREDIENTS**

| CAS# | Chemical Name | % | EINECS# |
|---|---|---|---|
| 7647-14-5 | Sodium Chloride | 25% | 231-598-3 |
| 7732-18-5 | Water | 75% | 231-791-2 |

**SECTION 3—HAZARDS IDENTIFICATION**
EMERGENCY OVERVIEW
*Appearance:* colorless
**CAUTION**! May cause respiratory tract irritation. May cause eye and skin irritation. May cause digestive tract irritation with nausea, vomiting, and diarrhea.
*Target Organs:* none
Potential Health Effects

*Eye*: May cause eye irritation.
*Skin*: May cause skin irritation.
*Ingestion:* Ingestion of large amounts may cause gastrointestinal irritation. Ingestion of large amounts may cause nausea and vomiting, rigidity or convulsions. Continued exposure can produce coma, dehydration, and internal organ congestion.
*Inhalation:* May cause respiratory tract irritation.
*Chronic:* No information found.

**SECTION 4—FIRST AID MEASURES**
*Eyes:* Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower lids. If irritation develops, get medical aid.
*Skin:* Get medical aid if irritation develops or persists. Flush skin with plenty of soap and water.
*Ingestion:* If victim is conscious and alert, give 2 to 4 cupfuls of milk or water. Never give anything by mouth to an unconscious person. Get medical aid if irritation or symptoms occur.
*Inhalation:* Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid if cough or other symptoms appear.
*Notes to Physician:* None
*Antidote:* None reported

**SECTION 5—FIRE FIGHTING MEASURES**
*General Information:* As in any fire, wear a self-contained breathing apparatus in pressuredemand, MSHA/NIOSH (approved or equivalent), and full protective gear.
*Extinguishing Media:* For small fires, use water spray, dry chemical, carbon dioxide, or chemical foam.

*Auto-ignition:* Temperature: Not available
*Flash Point:* Not available

*NFPA Rating:* Not published
*Explosion Limits, Lower:* Not available
*Upper:* Not available

**SECTION 6—ACCIDENTAL RELEASE MEASURES**
*General Information:* Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Flush spill area with water.

**SECTION 7—HANDLING AND STORAGE**
*Handling:* Wash thoroughly after handling. Use adequate ventilation. Avoid contact with skin and eyes. Avoid ingestion and inhalation.
*Storage:* Store in a cool, dry place. Store in a tightly closed container.

**SECTION 8—EXPOSURE CONTROLS, PERSONAL IDENTIFICATION**
*Engineering Controls:* Good general ventilation should be sufficient to control airborne levels.

Exposure Limits

| **Chemical Name** | **ACGIH** | **NIOSH** | **OSHA—Final PELs** |
|---|---|---|---|
| Sodium Chloride | None listed | None listed | None listed |
| Water | None listed | None listed | None listed |

*OSHA Vacated PELs:*
Sodium chloride: No OSHA Vacated PELs are listed for this chemical.
Water: No OSHA Vacated PELs are listed for this chemical.
Personal Protective Equipment
*Eyes:* Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN 166.
*Skin:* Wear appropriate gloves to prevent skin exposure.
*Clothing:* Wear appropriate protective clothing to minimize contact with skin.
*Respirators:* Follow the OSHA respirator regulations found in 29 CFR 1910.134 or European Standard EN 149. Always use a NIOSH or European Standard EN 149 approved respirator when necessary.

**SECTION 9—PHYSICAL AND CHEMCIAL PROPERTIES**
*Physical State:* Solid
*Appearance:* Colorless
*Odor:* Odorless
*pH:* Not available
*Vapor Pressure:* Not available
*Vapor Density:* Not available
*Evaporation Rate:* Not available
*Viscosity:* Not available
*Boiling Point:* Not available
*Freezing/Melting Point:* Not available
*Decomposition Temperature:* Not available
*Solubility:* Soluble in water
*Specific Gravity/Density:* Not available
*Molecular Formula:* Solution
*Molecular Weight:* Not available

**SECTION 10—STABILITY AND REACTIVITY**
*Chemical Stability:* Stable
*Conditions to Avoid:* High temperatures
*Incompatibilities with Other Materials:* Reacts with most non-noble metals such as iron or steel, building materials (such as cement), bromine, or trifluoride. Potentially explosive reaction with dichloromaleic anhydride + urea. Electrolysis of mixtures with nitrogen compounds may form

explosive nitrogen trichloride.
*Hazardous Decomposition Products:* Chlorine, toxic fumes of sodium oxide.
*Hazardous Polymerization:* Has not been reported.

**SECTION 11—TOXICOLOGICAL INFORMATION**
*RTECS#:*
CAS# 7647-14-5: VZ4725000
CAS# 7732-18-5: ZC0110000
*LD50/LC50:*
CAS# 7647-14-5: Oral, mouse: LD50 = 4 gm/kg; Oral, rat: LD50 = 3 gm/kg.
CAS# 7732-18-5: Oral, rat: LD50 = >90 mL/kg.
*Carcinogenicity:* Sodium chloride—Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.
Water—Not listed by ACGIH, IARC, NIOSH, or OSHA.
*Epidemiology:* No information reported
*Teratogenicity:* An experimental teratogen
*Reproductive Effects:* Human reproductive effects by intraplacental route: Terminates pregnancy; Experimental reproductive effects
*Neurotoxicity:* No information reported
*Mutagenicity:* Human mutation data reported
*Other Studies:* No information reported

**SECTION 12—ECOLOGICAL INFORMATION**
*Ecotoxicity:* No information found
*Environmental Fate:* No information reported
*Physical/Chemical:* No information found
*Other:* No information found

**SECTION 13—DISPOSAL CONSIDERATIONS**
Dispose of in a manner consistent with federal, state, and local regulations.
RCRA D-Series Maximum Concentration of Contaminants: None listed
RCRA D-Series Chronic Toxicity Reference Levels: None listed
RCRA F-Series: None listed
RCRA P-Series: None listed
RCRA U-Series: None listed
Not listed as a material banned from land disposal according to RCRA.

**SECTION 14—TRANSPORT INFORMATION**
*US DOT:* No information available
*IMO:* No information available
*IATA:* No information available
*RID/ADR:* No information available
*Canadian TDG:* No information available

**SECTION 15—REGULATORY INFORMATION**
*US FEDERAL*
*TSCA:*
CAS# 7647-14-5 is listed on the TSCA inventory.
CAS# 7732-18-5 is listed on the TSCA inventory.
*Health & Safety Reporting List:*
None of the chemicals are on the Health & Safety Reporting List.
*Chemical Test Rules:*
None of the chemicals in this product are under a Chemical Test Rule.
*Section 12b:*
None of the chemicals in listed under TSCA Section 12b.

*TSCA Significant New Use Rule:*
None of the chemicals in this material has a SNUR under TSCA.
*SARA:*
*Section 302 (RQ):* None of the chemicals in this material has an RQ.
*Section 302 (TPQ):* None of the chemicals in this product has a TPQ.
*CHEMICAL SARA Codes*
CAS# 7647-14-5: acute
Section 313: No chemicals are reportable under Section 313.
*Clean Air Act:*
This material does not contain any hazardous air pollutants.
This material does not contain any Class 1 Ozone depletors.
This material does not contain any Class 2 Ozone depletors.
*Clean Water Act:*
None of the chemicals in this product is listed as Hazardous.
*Substances under the CWA:* None of the chemicals in this product is listed as Priority.
*Pollutants under the CWA:* None of the chemicals in this product is listed as Toxic *Pollutant under the CWA.*
*OSHA:*
None of the chemicals in this product is considered highly hazardous by OSHA.
*STATE*
Sodium chloride is not present on state lists from CA, PA, MN, MA, FL, or NJ.
Water is not present on state lists from CA, PA, MN, MA, FL, or NJ.
California: No Significant Risk Level; None of the chemicals in this product is listed.
*European/International Regulations*
European Labeling in Accordance with EC Directives
Hazardous Symbols: Not available
Risk Phrases:
Safety Phrases:
*WGK (Water Danger/Protection)*
CAS# 7647-14-5: 0
CAS# 7732-18-5: No information available
*Canada*
CAS# 7647-14-5 is listed on Canada's DSL/NDSL List.
CAS# 7732-18-5 is listed on Canada's DSL/NDSL List.
*WHMIS:* Not available
CAS# 7647-14-5 is not listed on Canada's Ingredient Disclosure List.
CAS# 7732-18-5 is not listed on Canada's Ingredient Disclosure List.
Exposure Limits

**SECTION 16—ADDITIONAL INFORMATION**
*MSDS Creation Date:* 5/14/1996
*Revision #1 Date:* 9/02/1997

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no way shall [the manufacturer] be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if [the manufacturer] has been advised of the possibility of such damages.

## Storage Procedures

Factors that affect how you store materials in your storeroom include the properties of hazardous materials, patterns of storeroom organization, and proper procedures for storing and handling various materials. Computer software programs that contain chemical storage patterns are available.

To help keep your storage room organized, you might wish to code each shelf area by group or type of substance. Mark that code on the label of the substance with a waterproof marker to help ensure that the substance is returned to the correct shelf after use. Also enter the code in your inventory record. **WARNING:** *Do NOT return unused substances to the original container. Contamination can cause unwanted reactions.*

### The Nature of Hazardous Materials

Follow regulations for storing hazardous materials. (Check your MSDS file.) Follow all precautions when handling hazardous materials. Note that some materials might pose more than one type of hazard. Types of hazardous materials include:

- **Corrosives** Materials called corrosives can injure body tissues or damage metal by direct chemical reaction. Examples of corrosive acids are sulfuric, acetic, hydrochloric, and nitric acids. Examples of corrosive bases are sodium hydroxide and aqueous ammonia. Other corrosive substances include iodine, bromine, and ferric chloride.
- **Flammable Liquids and Solids** Liquids usually do not burn, but they often produce vapors that do. Examples are solvents such as acetone, ethanol, toluene, and glacial acetic acid. **WARNING:** *Vapors from flammable solids are as dangerous as those from liquids.*
- **Toxic Substances** Such substances enter the body by ingestion, skin contact, or inhalation. Acute effects of a toxic substance occur suddenly or within a few hours. For example, methyl alcohol can cause blindness or death if even small amounts are swallowed or inhaled. Chronic effects result from repeated exposure to a toxic substance over months or years and are dose dependent—calling for using the smallest amounts possible and following all precautions. Examples are benzene and formaldehyde.
- **Oxidizers and Reactives** These chemicals can explode, violently polymerize, form explosive peroxides, or are pyrophoric. Pyrophoric substances can ignite spontaneously when exposed to water or oxygen. Examples of oxidizers include nitric acid, hydrogen peroxide, and potassium nitrate and nitrite. Examples of substances that form hazardous polymers on aging include acrylonitrile and butadiene. Substances that can form explosive peroxides within a few months, include aldehydes, ethers, ketones, and vinyl compounds. Pyrophoric substances include calcium carbide, sodium, and magnesium powder.

- **Pathogens WARNING:** *All human, animal, and plant specimens present a potential hazard from pathogens.* Be selective in choosing microorganisms for laboratory activities. Reputable suppliers will list known or suspected pathogens in their catalogs. Today, most suppliers will not sell pathogens to schools. Purchase biological specimens in preservatives with low toxicity. Formaldehyde or formalin are no longer recommended as preservatives. Obtain an MSDS from suppliers for their holding and shipping fluid. Ethylene glycol is a significant ingredient in most nonformaldehyde preservative preparations. **WARNING:** *Ethylene glycol is toxic when ingested, even in small amounts. Use precautions. Thoroughly rinse specimens, wear gloves, and ensure good ventilation.*
- **Radioactive Materials** Radiation naturally occurs in some ores. Radioactive ores are largely regulated by the individual states. Overexposure to radiation can cause burns and cancer. Evaluate ores before use. They should not subject an individual to radiation levels of more than 5 millirems during an hour. Use ores for demonstration only. Do not allow students to handle radioactive ores.

## Chemical Compatibility

A major factor in storing and handling chemicals is knowing which chemicals work with other chemicals. Chemical compatibility describes how stable a substance is when mixed with another substance. If substances do not change when mixed, they are considered compatible. If substances form a chemical reaction when mixed, they are considered incompatible. For example, acids and bases react when mixed and are therefore considered incompatible. Acids should be stored together in a separate area from bases.

**General Storage Patterns and Procedures** The procedures that follow pertain to all areas, including earthquake-prone areas. For additional information, suppliers describe storage patterns in their catalogs. All items should be labeled with the name of the substance, its source, its acquisition and/or expiration date, hazard information, and necessary first aid steps to follow in the event of an emergency involving the substance. Chemicals should have chemical formula and concentration listed. Following are some additional suggestions for storing chemicals safely.

- Students should NOT have access to the storeroom area.
- **WARNING:** *Do NOT store hazardous substances above eye level and NEVER on the floor. Follow regulations regarding the storage of hazardous materials.*
- All storage shelves and cabinets should be securely attached to the walls. **WARNING:** *Do NOT place hazardous materials in unstable containers or in an apparatus that is not properly secured.*

- Larger equipment and larger chemical containers should be stored on lower shelves only.
- **WARNING:** *Do NOT store materials in direct sunlight.*
- Substances should be stored at the correct temperature.
- Storeroom temperature should be monitored on a regular basis.
- Poisons should be kept locked in a cabinet.
- Keep all containers of biological specimens in locked storage.
- Keep all syringes and scalpel blades in locked storage.

## Handling Radioactive Materials

Follow all regulations regarding how to handle radioactive materials. All sources should be shielded, handled, and transported in a manner to prevent anyone from being exposed to unnecessary radiation. Normally, "Caution: Radioactive Area" signs are posted when radioactive materials are present. However, NO school should have enough radioactive material (5 millirems) to warrant such a sign.

**WARNING:** *Dinosaur fossils might be radioactive and should NOT be in a classroom laboratory unless they test at safe levels of radioactivity*. Keep dinosaur fossils in sealed containers, and wash them before being handling (with gloves).

## Storing Chemicals

Store chemicals in a separate, dedicated room different from the preparation/equipment storeroom. Allow sufficient room to store chemicals according to compatible chemical families. Store according to the guidelines that follow only those chemicals you intend to use.

- Separate chemicals by reaction type. Store acids in one place and bases in another. Oxidants should be stored away from easily oxidized materials.
- Peroxide production in aldehydes, ethers, ketones, and vinyl compounds can be slowed by storing them in full containers, by closing containers as soon as possible, and by tightly closing the containers' lids or caps, which limits exposure of the container's contents to oxygen.
- Some pyrophorics are stored with a layer of mineral oil or kerosene over them to prevent contact with the air.
- Store any source of ignition separately from combustible materials. Ignition sources include sparkers, strikers, lighters, matches, lenses, and parabolic mirrors.
- Store water-reactive chemicals (metals) where they will remain dry.
- Store chemicals in an upright position and place them no more than two containers deep.
- **WARNING:** *Do NOT store chemicals in fume hoods.*

- Refrigeration might be required to minimize decomposition or volatility of certain substances. Use only spark-free refrigeration in laboratories, storage rooms, and preparation areas for storing flammable chemicals. **WARNING:** *Do NOT use laboratory refrigerators to store edibles.*
- Store acids and corrosives in a nonmetal or coated-metal, vented cabinet. The acid cabinet should be vented to the outside to prevent a buildup of toxic fumes. A separate nitric acid compartment or cabinet must be provided to separate nitric acid from other inorganic acids or readily oxidized substances.
- Store flammable reagents in the smallest quantities possible. Store flammable liquids in appropriate safety cabinets and/or safety cans. **WARNING:** *Do NOT store flammables in a householdtype refrigerator. Instead, use an explosion-proof refrigerator.*
- Chemical shelving should have restraints to contain the chemicals. **WARNING:** *Use caution when removing containers from shelves with lips so that they do not catch on the lip and tip over and spill.*
- For more information, refer to the Chemical Incompatibility Reference Sheets on the next two pages.

## Handling Live Animals

Animals require specific diets and living conditions. Check with reliable sources about an animal's requirements and ensure they can be met before bringing the animal to school. If you intend to keep an animal over the course of one or more school years, consider how the animal's needs, particularly those for space, will change over time as the animal grows. If the animal's needs cannot be met on an ongoing basis, then consider keeping a different animal or have a plan in place for what will happen to the animal when its needs can no longer be met in the classroom. Remember that because animals need full-time care, you must make arrangements for weekends and holidays.

Consider students' allergies before bringing animals into the classroom. Any pet brought to class should have a clean bill of health from a veterinarian and mammals should be vaccinated for rabies. Contact special events directors regarding the use and handling of animals in science fairs and other research projects. Remember above all to treat animals with care and respect.

## Chemical Incompatibility Reference Sheet

| Chemical | Not compatible with |
|---|---|
| **Gasses** | |
| Acetylene | Bromine, chlorine, copper, fluorine, mercury, silver |
| Ammonia (anhydrous) **WARNING:** *This chemical is deadly by itself.* | Bromine, calcium hypochlorite, chlorine, iodine, mercury |
| Hydrocarbons (such as butane and propane) | Bromine, chlorine, chromic acid, fluorine, sodium peroxide |
| Hydrogen sulfide **WARNING:** *This chemical is deadly by itself.* | Fuming nitric acid, oxidizing gases |
| Oxygen | Oils; grease; hydrogen; flammable liquids, solids, or gases |
| **Liquids** | |
| Acetic acid | Ammonium nitrate, chromic acid, ethylene glycol, hydroxyl compounds, nitric acid, perchloric acid, permanganates, peroxides |
| Acetic anhydride | Water |
| Acetone | Concentrated nitric and sulfuric acid mixtures |
| Aniline | Hydrogen peroxide, nitric acid |
| Flammable liquids | Ammonium nitrate, chromic acid, halogens, hydrogen peroxide, nitric acid, sodium peroxide |
| Hydrogen peroxide (6% or more) | Acetone, alcohols, aniline, chromium, combustible materials, copper, iron and iron oxides, most metals and their salt, organic materials |
| Mercury | Acetylene, ammoni |
| Nitric acid (concentrated) | Acetic acid, alcohol, aniline, brass, copper, flammable gases and liquids, heavy metals, hydrogen sulfide, phosphorus |
| Oxalic acid | Mercury, silver |
| Sulfides | Acids |

## Chemical Incompatibility Reference Sheet (continued)

| Chemical | Not compatible with |
|---|---|
| Sulfuric acid | Carbohydates, most metals, potassium chlorate, potassium perchlorate, potassium permanganate and other similar compounds of light metals such as sodium or lithium, reducing agents |
| Toluene | Strong acids, strong oxidizing agents |
| **Solids** | |
| Alkali and alkaline Earth metals (powdered Al or Mg, Ca, Li, Na, K) | Carbon dioxide, chlorinated hydrocarbons, halogens, water |
| Aluminum metal | Ammonium nitrate; antimony trichloride; bromine vapor; any bromate, chlorate, or iodate |
| Ammonium nitrate | Acids, chlorates, flammable liquids, nitrites, powdered metals, sulfur, finely divided organic or combustible materials |
| Calcium oxide | Water |
| Carbon (activated) | Calcium hypochlorite, all oxidizing agents |
| Chlorates | Acids, ammonium salts, powdered metals, sulfur, finely divided organic or combustible materials, reducing agents |
| Copper | Acetylene, hydrogen peroxide |
| Cyanides<br>**WARNING:** *This chemical is deadly by itself.* | Acids |
| Iodine | Acetylene, ammonia, hydrogen |
| Nitrates | Reducing agents, sulfuric acid |
| Nitrites | Acids |
| Potassium | Carbon dioxide, water |
| Potassium permanganate | Ethylene glycol, glycerol, sulfuric acid |
| Selenides | Acids, reducing agents |
| Silver | Acetylene, ammonium compounds, oxalic acid, tartaric acid |
| Sodium | Carbon dioxide, sulfur, water |
| Sodium nitrate | Ammonium nitrate and other ammonium salts |
| Sodium peroxide | Acetic anhydride, carbon disulfide, ethylene glycol, ethyl acetate, ethyl or methyl alcohol, glacial acetic acid, glycerin, methyl acetate |

## Inventory Practices

Use the following tips as a guide to cataloging and maintaining laboratory materials.

- A computer inventory program can simplify the process of finding a substance. An alphabetized printout, manual listing, or file card system also works well. Information should include all items on the label plus the type of substance (chemical, biological, radioactive, and so on), condition, amount, size of container, and location in the storage room.
- Conduct periodic (at least once a year) inspections and cleanup efforts. For your personal safety, two individuals (NOT students) should be involved. Safety devices, such as goggles, masks, aprons, and gloves, should be worn. The storeroom should be well-ventilated.
- Check stored substances for signs of leakage, deterioration, loose labels, or other potentially dangerous conditions.
- Control the amount of substances you have on hand. Check regulations for your area to find out what the legal limit is.
- Reduce your inventory by ordering only those substances needed in the next year or so.
- Take steps to dispose of all outdated, contaminated, and unlabeled materials.
- Dispose of those substances that have not been used in the last year or two as well as hazardous materials that should not be used in a classroom/laboratory.

If possible, purchase materials by school or school district to

- prevent duplication and to buy in bulk for lower prices. **WARNING:** *Substances purchased in bulk and then transferred to smaller containers for individual schools MUST be labeled properly and placed into proper containers. Follow all safety regulations in the transfer of the substances.*

## Waste Disposal Policies

This section discusses issues involved in waste generated from wholesale cleanup of a laboratory and storage room and possible methods of disposal to include in your policies and waste disposal plans. **WARNING:** *If you store non-hazardous wastes with hazardous wastes, the entire contents of the storage MUST be considered hazardous waste.*

### Reducing Waste

An important step in managing waste disposal is finding ways to reduce the amount of waste you generate. Reducing the amount of waste produced reduces the costs of disposal and fosters a safer environment in the science laboratory. Consider the following:

- Buy only the amount of chemicals you will need within the

- Many chemistry labs contain chemicals that were purchased in bulk years ago and that either have degraded or are no longer needed. Any initial savings in bulk purchases will therefore be thrown away. Costs of waste disposal increase when the disposal involves old and unstable materials.
- Students should NOT work with hazardous chemicals, and it is expensive to dispose of them as regulated waste. When you discontinue use of a hazardous chemical, any amount remaining in the inventory will require legal disposal as a hazardous waste. Be sure not to order more. Substitute non- or lesshazardous chemicals for hazardous chemicals in experiments.
- Use cyclohexane in place of benzene in molecular weight determination and freezing point experiments.
- Store biological specimens in isopropyl alcohol, sodium citrate, or other preservative safer than formaldehyde.
- Use cyclohexane in place of carbon tetrachloride in halide-ion tests.
- A 40-percent glyoxal solution can be substituted for formalin (a 40-percent formaldehyde solution) in some demonstrations.

## Chemical Disposal

Local, state, and federal laws regulate the disposal of chemicals. Consult these laws before attempting to dispose of any chemicals. Prior to chemical disposal, identify which chemicals need to be disposed of. These include

- out-of-date or contaminated chemicals;
- chemicals without legible labels;
- chemicals that are too hazardous for student use.

**WARNING:** *Some substances should NOT be removed from storage except by certified teachers. Some of these include benzoyl peroxide, carbon disulfide, diisopropyl ether, ethyl ether, perchloric acid, and potassium metal. NOTE: Picric acid is outlawed for school use—if any is found in a school lab, trained officials must be called.*

Store wastes in tightly closed, compatible containers. For example, do not store acid or caustic wastes in metal containers. **WARNING:** *Do NOT mix organic and inorganic wastes.* **WARNING:** *Do NOT mix halogenated and non-halogenated solvents.*

## Where to Dispose of Chemicals

Federal, state, and local laws regulate the amount and kinds of chemicals that can be put in a landfill or into the sewage system. Check with your school district. It might have a waste management program to help teachers recognize hazardous waste and understand proper disposal. Then check with local officials regarding laws for disposing of unknown substances. Possible sources of places that handle chemical waste include

- commercial chemical disposal companies in your area;
- some local industries;
- colleges and universities that have facilities for disposal available for school use.

## How to Dispose of Chemicals

There are several options for substance disposal, but each school or school district must make its own arrangements according to local restrictions of landfills, sewer systems, or other treatment works. **WARNING:** *Be sure you check your state and local regulations before you use any of the following methods:*

- carbon absorption
- oxidation/reduction
- precipitation and clarification
- biological treatment
- land disposal

Here are some additional things to remember when deciding how to dispose of unneeded chemicals:

- Usable chemicals might be accepted by colleges, researchers, industry, or other schools. Contact the local American Chemical Society for suggestions. This method works best if direct communication is made with someone known to the person making the contact.
- You might be able to consolidate your waste with that of other local schools for more efficient disposal.
- **WARNING:** *Follow state and local regulations regarding the transportation of chemicals.*
- SOME hazardous wastes can be treated so that they are non- or less-hazardous. For example, acids or bases can be carefully neutralized to a final pH range of 5–8 and then flushed down the drain with a 20-fold excess of water. Sodium bicarbonate is used to raise pH, and 1*M* hydrocloric acid is used to lower pH. **WARNING:** *Pouring certain chemicals down the sink or other drains may interfere with some chemicals that are used in water treatment processes.*
- Some waste disposal companies recycle chemicals and resell them.
- Recover laboratory wastes. Recovery of chemicals can be a learning tool for students, and can be presented as the final step in a chemistry experiment or as a project for more advanced students. University chemistry departments, the Internet, and the Environmental Protection Agency offer information about chemical recovery.

## Prepare Live Exhibits

Aquariums and terrariums are useful for maintaining living organisms, such as small plants and animals, to study as a class. You can use any glass or plastic container (4 L or larger) with a cover as an aquarium or terrarium. Wash and rinse the container thoroughly before you use it.

Instructions follow for preparing aquariums and terrariums and for growing plants.

### Aquariums

1. Place washed aquarium gravel on the bottom of the container to a depth of 4 cm.
2. Add aged tap water to a depth of 5 cm above the gravel. To age tap water, allow it to sit in an open container for three days so that any chlorine in it can dissipate.
3. Anchor aquatic plants, such as eel grass, in the gravel.
4. Fill the aquarium by pouring aged tap water over a saucer to avoid disturbing the gravel on the bottom.
5. Let the aquarium stand for one day.
6. Add guppies, goldfish, snails, duckweed, and other organisms. (Recall that adult guppies eat smaller fish, so keep young and adults separated.)
7. Suspend a thermometer in the water to monitor the temperature. Maintain a temperature of 20–25°C. A lamp or sunny window can supply light and warmth.
8. Cover the aquarium.
9. Ensure that the cover of the container allows for air circulation.
10. Add small amounts of high-protein baby cereal or special fish food daily. Snails will eat any food the fish do not consume.
11. Keep the plants pruned so they do not fill the tank.
12. Keep tap water aging to replace any water lost by evaporation.
13. If algae develop in the aquarium and turn the water green, do not discard the water. It is an excellent source of food for other organisms.

### Terrariums

1. Place pebbles on the bottom of the container to a depth of 2 cm.
2. Add 1 cm of clean sand and then 3 cm of topsoil.
3. Place a layer of healthy green moss on top of the topsoil.
4. Plant several clusters of small ferns and liverworts. You can also add lichens.
5. Place interesting rocks and driftwood in the terrarium.
6. Cover the terrarium.
7. Place the terrarium in filtered light.
8. Keep the plants moist by sprinkling with water occasionally. The pebble and sand layers allow for drainage. If water accumulates in the pebble layer, do not add more water until there is no more standing water.

## Plants

You can grow plants in the laboratory from seeds or from cuttings. Bean plants, coleus, geraniums, and philodendrons usually grow well and often can be obtained at relatively low cost from nurseries and local gardening centers.

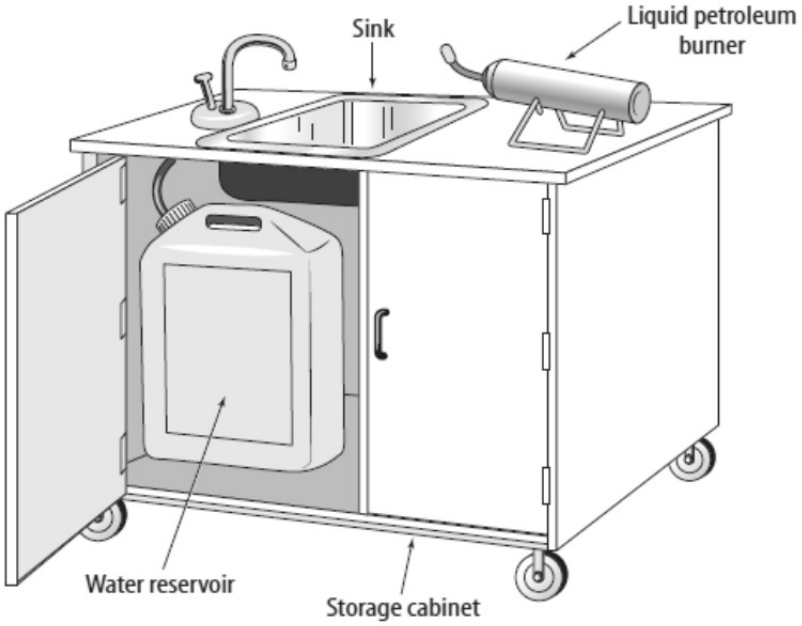
1. Place packaged potting soil 5 cm deep in the bottom of a clean milk carton or plastic sandwich bag. Poke holes in the bottom of containers to ensure good drainage. Place containers on a plastic tray to catch water runoff.
2. Plant seeds or cuttings from other plants.
3. Keep the soil moist.
4. Many kinds of seeds germinate within two weeks. Radish and bean seeds grow especially quickly. Cuttings of many kinds of plants should root in two to four weeks. (Cuttings from plants like coleus and philodendron can be rooted in water alone.)
5. Place coarse sand or pebbles in the bottom of pots for drainage.
6. Transplant the seedlings or rooted cuttings into the pots. Place the pots on a tray to collect excess water.
7. Water occasionally. Do not over-water. Rotting stems and roots and yellow or brown leaves can indicate overwatering.
8. Place the plants in a warm, lighted area. Leaf-curling is a sign of too much heat. Dropping leaves often indicates a lack of humidity.
9. Add a weak solution of plant food every two to three months to supply nutrients.

## Check Facilities and Equipment

Surveying your facilities and knowing what you have to work with is a very important step in managing the success and safety of your students. You'll need to keep in mind the number of students in each class and how many labs you'll be teaching.

If you are not the only teacher using the science classroom and lab facilities, you and your colleagues should complete the survey of lab facilities as a team. If you have more than one lab facility available, you might wish to consider setting up each one for a specific use. Your school can realize savings if you set up Earth science equipment in one lab, physical science equipment in another, and life science materials in a third.

You might find that a portable demonstration cart will add flexibility to your teaching. If each teacher has a cart, he or she can move his or her cart to a specific lab facility as needed, or use it for demonstrations in the classroom. The cart also can be used for small group activities. Demonstration carts are available from scientific suppliers. They usually contain a work space, sink, propane gas torch or burner, water reservoir, and storage cabinet. **WARNING:** *Do NOT store hazardous materials in the cart.*



## Facilities Specifications

This section presents information on various aspects of school science buildings, such as recommended amounts of space for student work areas and storage needs for a well-managed science classroom/lab. This section also gives basic specifications for builtin features for fire control and air quality.

**Space Requirements** Overcrowding is a leading cause of lab accidents, and it interferes with student learning. Space requirements include a minimum amount of space for student work areas and room for separate storage and preparation areas. Check with your school's administration to make sure that your laboratory area meets your local and state regulations regarding space requirments. Making sure that there is sufficient space for student's to work safely is an important consideration in setting up your laboratory area and your classrooms.

**Student Work Areas** Generally, state regulations stipulate a certain amount of square footage per student per instruction level or a certain number of students per laboratory. The net square footage includes exposed storage space, such as cabinets or shelving. The square footage does NOT include hallway space, storage closets, or preparation offices. Check these regulations to be certain that your space requirements comply.

**Technology Stations** Placing technology stations in the classroom laboratory increases the requirements for the size of that room. If you add such stations to your laboratory, the number of students should decrease accordingly for the lab activities. Again, check with your school's administration to make sure that you are meeting all government requirements regarding space allocations in your classrooms and laboratories.

## Preparation and Storage Areas

- **WARNING:** *Do NOT use a storage room to prepare materials for laboratory investigations.*
- Store equipment and materials separately from the classroom laboratory and the preparation room and according to local and state regulations.
- Set up storage for chemicals, biological specimens, and expensive equipment you or your students use on a daily basis.

State and local regulations often control the ways you may store materials on school property. Check with the school administration for advice on the safe storage of materials. Some schools have labprep personnel who help maintain science material inventories and who also help set up laboratory investigations. If your school employs these people, they should be aware of all government regulations. They are a good source of information about laboratory safety and the proper storage of science materials. There are also printed and internet sources of information that can guide you in the safe storage of materials.

**Fire Control Features** In the event of fire, science classrooms must meet minimum requirements set by the National Fire Protection Association (NFPA) and local fire officials. These include such requirements as:

- Each science room, preparation room, and equipment/materials storage room MUST have two clearly marked emergency exits. One of the exits in a ground-floor room may be a window if it is large enough for an adult to escape through.
- Fire extinguishers should be placed at eye level at every exit.
- All rooms should have a sprinkler system.
- All rooms should have a smoke alarm.
- There MUST be a general fire alarm system throughout the building.
- You MUST post and practice fire-drill procedures.
- Keep a fire blanket at eye level near each fire extinguisher. Clearly mark it, and make it easily accessible.
- All utilities should have a master cut-off control switch. These should be easily accessible by teachers but not so handy to students. Label the controls clearly to mark to the room location and type of utility.
- **WARNING:** *Do NOT use stairways and hallways as storage areas.*
- **WARNING:** *NEVER block access to exits, emergency equipment, control switches, and so forth.*

**Electrical Systems** Apart from the danger of electrical shocks, fires in the classroom laboratory commonly result from misuse of electrical power and equipment. Follow local and state government building codes in all cases regarding sources of electricity and the kinds of outlets that are safe to use in laboratories. Give special consideration to laboratory areas that also have sources of water. An electrical contractor in your area will be aware of all building codes relating to the safe installation and maintenance of all electrical outlets. Make sure that you have a fire extinguisher that is rated for use in putting out electrical fires in any areas where people will be working with electricity.

**Air Quality Control Science Classrooms, Laboratories, Fume Hoods, and Storage Areas** Proper ventilation systems contribute to a safe environment for you and your students. These systems will vary depending on the use of the classroom and laboratories involved. Follow all government regulations that regulate ventilation equipment in any areas of your school that are used for science investigations, as well as for material storage. These areas will have different regulations than other parts of your school's building. In most cases, the class, laboratory, and storage areas need ventilation equipment that provides for a rapid exchange of air. These regulations are designed to prevent the toxic buildup of gases that laboratory work can produce. You can obtain additional safety information from American National Standards Institute (ANSI) Z9.5.

Remember, when dealing with things like fire control features, electical systems, and air quality control, your local fire officials can be one of your best sources of information regarding local requirements.

## Safety Equipment Specifications

The same general guidelines for investigation equipment apply to safety equipment. You can group safety equipment according to use. You use one group of equipment for personal protection as a precaution. Another group contains the equipment you will need to deal with accidents if they occur. You can find details for the appropriate use of this equipment in the section titled “Emergency Response”.

**Personal Protection Equipment** You MUST wear personal protection equipment if there is a chance of exposure to harmful substances. Some school districts require all individuals to put on goggles and aprons before they enter the laboratory.

**Eyewear** All lab activities, in the laboratory or out, require safety goggles. Check your local and state regulations for the preferred code. This code will appear on the frames and lenses. Several types of eyewear are available. They are NOT the same. The type of eyewear you and your students wear MUST be appropriate to the activity.

- Chemical safety goggles should be large enough to protect the eyes and form a seal around them. Chemical safety goggles should also be able to form a seal around eyeglasses without affecting the vision correction afforded by the eyeglasses. **WARNING:** *Contact lenses can trap chemicals (even vapors) against the cornea and cause damage. It is best not to wear contact lenses in a lab that requires chemical safety goggles.*
- Laser goggles are rated for the wavelength and power of a particular laser. One type of goggles is NOT automatically usable with any type of laser. **WARNING:** *Chemical safety goggles are NOT suitable for work with lasers.*
- **WARNING:** *NO devices are approved to protect the eyes against direct viewing of the Sun.*

**Gloves** Wear gloves to protect hands against heat, sharp objects, chemicals, body fluids, and so forth. **WARNING:** *One kind of glove will NOT protect hands against all hazards. Certain gloves can dissolve when they come in contact with a solvent.* Make sure the glove type is appropriate for the activity. Supplier catalogs often include a list rating of the effectiveness of certain materials in protecting against particular substances. As an alternative, refer to the manufacturer’s MSDS if there is a question regarding which type of glove to use with a certain chemical.

- *Polyethylene gloves* protect hands against light corrosives and irritants.
- *Latex gloves* protect against biological materials. Change them as soon as they show soil. **WARNING:** *Some people have an allergic reaction to latex.*

- *Hypoallergenic latex gloves*, while more expensive than regular latex, are available. You can also wear cotton gloves beneath latex, neoprene, and nitrile gloves to protect against irritation.
- *Natural rubber gloves* help protect against electrical shock and light corrosives.
- *Neoprene gloves* provide protection against mineral acids and alcohols.
- *Nitrile gloves* are resistant against solvents, punctures, and abrasion.
- *Oven mitts* should be used when dealing with heat sources and heated materials or extreme cold.

**Clothing/Body Protectors** Wear laboratory aprons and coats to protect skin and clothing from spilled materials that might be hazardous. Protective clothing comes in many types of material.

- Aprons and lab coats made of multiple layers offer protection from permeation.
- **WARNING:** *Check to be sure that the protective material is flame retardant.*
- Aprons should have bibs that tie closely to the lower part of the neck. They should cover the body at least to the knees. Wear them over clothing. Wear clothing in lab that covers the arms and fits closely.

**Face Masks** Face masks offer protection against dust, allergens, and vapors. Some people are allergic to odors that might not be classified as hazardous to most people. Masks are available that offer varying degrees of protection, depending upon the need.

**Waste Disposal Containers** Equip every lab with the proper containers for the various kinds of waste that you and your students might produce. For example, biohazardous sharp objects must be placed in a puncture-proof container. Properly label waste containers and place them in a location that is convenient but out of the way of heavy traffic. Waste containers require proper storage and ventilation.

**Accident Response Equipment** This section deals with the specifications for accident response equipment.

**Eyewash Stations** An eyewash station MUST be available where chemicals are used, including classrooms and preparation rooms. An eyewash station should be reachable within 10 seconds (or 25 feet) by anyone in the classroom who has been splashed. It is best practice to wash chemicals from the eyes as soon as possible. Plumbed fixtures that deliver large quantities of water quickly are generally more efficient than plastic squeeze bottles. Dilute the chemical in the eye or eyes as quickly as possible. You should follow all state and local guidelines when installing eyewash equipment.

**Safety Showers** Many schools have safety showers in their laboratories, especially in chemistry laboratories. These showers deliver a large amount of water to quickly wash chemicals that may have splashed or spilled on a person working in the laboratory. Like eyewash stations, safety showers deliver a large amount of water quickly. This large volume of water dilutes the chemicals that spilled. You should follow all government regulations regarding the installation and maintenance of saftey showers.

**Fire Blankets** Specially treated wool fire blankets should be available in all science laboratories where hazardous chemicals are used or stored.

**Fire Extinguishers** Every classroom and laboratory should have fire extinguishers. In cases of large areas, several fire extinguishers might be needed. Check with local authorities to make sure that your classrooms and laboratories comply with all fire department regulations. Using proper equipment is extremely important in fighting fires. There are several classes of fire extinguishers, and each one effectively quenches a specific type of fire. Fire extinguishers are labeled for the class of fire for which you should use them. Remember to check extinguishers at the beginning of the school year to make sure that the material in the extinguisher is still able to put out a fire. In many localities, a professional service or the local fire department inspects and labels fire extinguishers.

**Table 1**

| Fire Class | Methods of Extinction | | Precautions |
|---|---|---|---|
| Class A: ordinary solid combustibles (paper, wood) | Water | Dry chemical class ABC fire extinguisher | NEVER use water on class B, C, or D fires. |
| Class B: flammable liquids (acetone, alcohol, ethers, grease) | | Class B or dry chemical class ABC fire extinguisher | |
| Class C: electrical or static charges | | Class C or dry chemical class ABC fire extinguisher | The extinguishing material in a Class C extinguisher will not conduct electricity. C is always used with other letters on an extinguisher. |
| Class D: combustible metals (magnesium, postassium, sodium) | Dry, clean sand | Class D fire extinguisher | Dry, clean sand is suitable for small fires; NEVER use water on combustible metals—some might react violently with water. |

**Materials for Chemical-Spill Cleanup** Cleanup materials should be items that quickly absorb liquids or substances that neutralize an acid or caustic spill. Cleanup materials are available from chemical supply companies. Follow state and local regulations for materials and procedures to follow for chemical spills.

**First Aid Kits** Keep first-aid supplies readily at hand. A capable person can give immediate aid while waiting for the school nurse or emergency squads. At a minimum, supplies should include the following:

- Recommended items for first-aid kits:
  - disposable gloves (latex or plastic)
  - antiseptic
  - disinfectant
  - bleach (at time needed, prepare a solution of 1 part bleach to 10 parts water)
  - disposable towels
  - sterile gauze for covering open wounds
  - medical tape
  - scissors
  - adhesive bandages for covering small wounds
  - plastic bags for holding contaminated waste
- Items NOT recommended for first-aid kits
  - iodine **WARNING:** *Iodine can cause tissue damage.*
  - ice pack compress **WARNING:** *Swelling of soft tissues should be examined by a physician.*
  - ammonia inhalants **WARNING:** *If person is unconscious, get help immediately.*
  - tourniquet **WARNING:** *Use hand pressure until medical assistance is available. Wear protective gloves and a thick gauze pad to avoid contact with blood.*

Local authorities might recommend additional materials. Check with your local Red Cross for assistance. In many areas, they might be willing to conduct a survey of your classrooms and laboratories and make recommendations about appropriate first aid materials to keep on hand. Your school nurse or physician can also make suggestions about materials that you should keep readily accessible for emergencies.

## Safety Requirements for Investigation Equipment

Following some basic precautions regarding laboratory equipment can greatly reduce common hazards.

### General Equipment Guidelines

- Keep manufacturer's instructions for proper usage techniques as well as safety precautions for equipment.
- Protect equipment from dust, humidity, and extreme temperatures, especially electronic equipment and microscopes.
- In earthquake-prone areas, clamp equipment to the table top.
- All electrical equipment should be 110-volt approved by Underwriters Laboratory or other equivalent. Locate all outlets, surge protectors, and cords well above floor level.
- Work surfaces should NOT have cracks or areas inaccessible to cleaning.
- All work surfaces should be water-, heat-, and chemical resistant.
- Control noise levels. Sustained noises above 80 decibels can cause or lead to hearing damage. **Table 2** shows guidelines regarding exposure to noise.

**Table 2**

| Sound Level Limits | | | |
|---|---|---|---|
| **Sound level (decibels)** | **Exposure limit** | **Typical source** | **Resulting hearing damage (after exposure limit)** |
| 150 | 0 s | jet plane taking off | ruptured ear drum |
| 120 | 7 min 30 s | chain saw, live rock music | pain and serious damage |
| 110 | 30 min | power saw, rock music | |
| 105 | 1 h | snow blower | serious damage |
| 100 | 2 h | woodworking shop | |
| 95 | 4 h | electric drill | |
| 90 | 8 h | tractor | damage |
| 85 | 8 h | electric shaver | possible damage |
| 80 | None | mini-bike | |

## Specific Guidelines for Commonly Used Equipment

### Heat Sources

- Hot plates with a flat surface (NOT coils) are recommended for heat sources. **WARNING:** *Hot plates stay hot after they are unplugged or turned off. Some hot plates have warning lights to show they are hot.* Be sure that you have an adequate number of outlets for the hot plates (one outlet per hot plate).
- A high temperature burner with a grid produces excellent results for bending glass. If your laboratory has gas burners, you and your students MUST use them with the appropriate type of gas. A manual central cut-off valve should be accessible to the teacher. **WARNING:** *NEVER use open flames when a flammable solvent is in the same room.*
- Alcohol burners are NOT recommended. **WARNING:** *Alcohol burners can explode in the event of a fire.*

**Thermometers** Digital thermometers are recommended. Some cities now prohibit the sale of mercury thermometers. If accuracy requires you to use a mercury thermometer, use one with a coating that helps contain the mercury even if the glass breaks. **WARNING:** *Mercury exposure to can cause nerve damage and developmental problems in small children.*

**Refrigerators** Cold storage is often recommended for certain materials, such as biological specimens and some flammable solvents. Specifications for laboratory refrigerators include the following:

- An explosion-proof refrigerator is recommended for storing flammable materials. These refrigerators have modified internal wiring and sealed motors and switches to prevent sparks. **WARNING:** *Control switches and defroster heaters in a home refrigerator can spark, which can ignite flammable materials.*
- A refrigerator used for storing radioactive materials MUST have the standard symbol for radioactivity on the door. The refrigerator should be checked periodically for radioactive contamination. **WARNING:** *NEVER store food in a science storage refrigerator.*
- In earthquake-prone areas, refrigerators should have secure closing devices. Older magnetic locks have not always proved effective during earthquakes.

**Glassware** Most injuries in the classroom laboratory are cuts that result from broken glassware. Use the proper kinds of glassware in order to greatly reduce the chance of injuries.

- Glassware should be heat-resistant.
- Glassware also should offer resistance to chemicals and accidental breakage.

**Batteries**

- Alkaline or dry-cell batteries are recommended for classroom use.
- Use storage batteries only when you need a larger DC current. **WARNING:** *Storage batteries contain acid and have the ability to deliver sufficient current to cause wire insulation to ignite.*

**Lasers** The Bureau of Radiological Health classifies lasers according to the amount of power they emit—Class I to Class IV. Those recommended for secondary schools are Class II and III-A lasers. **WARNING:** *Even low-powered lasers may cause eye damage.*

**Acceleration Models** Two common types of acceleration models are rockets and steam engines. Following safety standards and procedures can reduce hazard levels, which include the possibility of hearing damage.

- **Rockets** Some common recommendations for rockets include the following:
  - Rockets should be made of lightweight materials.
  - The rocket, including the engine, should NOT weigh more than 453 g.
  - The engine should NOT contain more than 133 g of propellant.
  - Use only a solid propellant and a factory-made engine.
  - Remote-controlled launches in open areas are recommended; students should be at least 5 m from the rocket.

**WARNING:** *Students should NOT rework or reload the engines; an explosion could result.*

- **Steam Engines** Steam engines with solid fuel burners are recommended for classroom laboratories. **WARNING:** *Alcohol fuel is NOT recommended. Pure alcohol burns with an invisible flame. If you add additional alcohol to the burner because it appears the flame has gone out, vapors and the stock can of alcohol can ignite.*

## Emergency Response

Many of the tools and chemicals in the science laboratory can cause injury or allergic reactions if you use them without proper attention and care. Allergic reactions can be in the form of swelling or hives, muscle cramps, disorientation, unconsciousness, and death from shock or suffocation. Even with the best efforts at prevention, emergencies still occur. Therefore, along with practicing effective safety measures, you also must be prepared to act quickly according to the given situation.

Obtain medical help in every case of serious injury or illness, in all cases of injury to the eye, and whenever in doubt. **WARNING:** *A teacher should NOT diagnose or treat injury or illness, or offer medication, but should offer necessary first aid until medical help is obtained*. After you contain an emergency, file an accident report whenever there is any injury to a student and/or property damage, even if an accident report is not required.

## Very First Steps

In cases of emergency, seemingly different responses need to take place simultaneously—calling 911 or other emergency number, getting the school nurse, using the safety equipment, administering first aid, and so on. Memorize the following first steps as they pertain to different kinds of emergencies.

1. **Keep calm** in all cases and **call 911** or other emergency number.
2. **In case of injury,** send a student to get the school nurse, if available, or the principal.
    - If the victim is not breathing, restore breathing if you have the training to do so.
    - Stop any bleeding by applying a light pressure, wearing protective gloves. **WARNING:** *If an object is in the wound, do NOT remove the object.*
    - Prevent shock. A clean fire blanket is useful for keeping an accident victim warm to help prevent shock .
    - Contact the parent or guardian as soon as possible.
3. In case of fire, begin evacuation and sound the alarm immediately.
4. In case of chemical spill, place affected student in the safety shower or use eyewash station if the spill affects the eyes.

## First Steps in Detail

**In Case of Injury** If a student receives a wound that causes severe bleeding or if the student is unconscious, send for the nurse and call 911 or another emergency number. If the injury is severe but the victim is ambulatory, accompany the person to the nurse's office. The nurse should

- administer additional first aid;
- contact the injured person's parent or guardian;
- pursue additional treatment as needed;

If a nurse is not available, contact a parent or guardian and advise him or her of the accident's severity and obtain permission to proceed with treatment as needed.

If you cannot reach a parent or guardian, you must act in accordance with the seriousness of the situation. If an emergency medical form exists that grants permission for emergency health care to be administered, call a physician. On the physician's advice, seek treatment for the injured student.

**In Case of Shock** Causes of shock include electrical charges from equipment and outlets and from lightning, severe allergic reactions, and other illnesses. A person suffering from shock might be unconscious, dazed, weak, and/or confused, or might even stop breathing. If you witness a student going into shock, you should

- call for emergency medical aid immediately;
- check for breathing and pulse immediately;
- keep the injured person warm, quiet, and lying down;
- elevate the feet a few inches if there are no chest or head injuries;
- start CPR if necessary and if you are trained to do so;

- if the shock is from electricity, carefully separate the person from the electrical source. **WARNING:** *Make sure you have dry hands and are not standing on a wet floor.* **WARNING:** *Do NOT use a metal object or other conducting material to separate the victim from the power source.*
- use the master control switch to shut off the electricity;
- check for entrance and exit burns; treat burns as you would a thermal burn, keeping in mind that some burns might be large and below the skin.

### In Case of Fire

- Evacuate the students, sound the fire alarm, shut off master switches in the classroom for gas and electrical power (if available), close windows and doors if possible, and then determine whether it is feasible to try to put out the fire. Be informed regarding which type of fire extinguisher to use and the proper use of fire blankets. **WARNING:** *If the fire is spreading or could block the escape route, leave immediately and let professionals fight the fire.*
- You can use cloth towels or fire blankets to smother a small fire.
- Inform students of the priority to first stop, then drop, and then roll in order to put out clothing fires.
- **WARNING:** *Do NOT use a fire extinguisher on a person, as serious chemical burns or frostbite can result.*

**In Case of Chemical Spills** If a chemical spill occurs in the laboratory or in the classroom, quick action can reduce the possibility of injury to a student or teacher. A chemical spill such as a liter bottle of hydrochloric acid breaking in the chemistry laboratory is considered a major spill.

- Immediately evacuate all students through the exits farthest from the spill. Fumes from a chemical spill can cause severe damage to the body.
- Immediately assist any person splashed with the chemical to the safety shower.
- Turn on the emergency exhaust fan.
- Contain the spill wearing the proper protective clothing. **WARNING:** *Do NOT allow the spill to trap you.*
- Call for help. The school safety plan should contain the numbers of agencies or departments in your community that will assist in containment and removal of the chemical.
- For materials entering the eye, rush to the eye wash station. The first response prior to medical treatment for a student or teacher who has hazardous material in the eye is to flush with water to dilute chemicals, wash out debris, or irrigate the eyes. (See below for techniques for using the eyewash station.)
- In case of mercury spills, provide maximum ventilation and avoid all contact with skin, clothing, or shoes.
- In case of biological contamination, use gloves during first aid and in cleaning up blood and other bodily fluids.

# Using Accident Response Equipment

## Eyewash Stations

- Begin washing the face, eyelids, and eyes as soon as possible, and continue for at least 15 min. The eyelids should be open, rotating the eyes as much as possible so water can flow on all surfaces and in the folds surrounding the eyeballs to ensure removal of the chemical.
- **WARNING:** *Do NOT rely on spray bottles as a substitute for eyewash stations.*
- **WARNING:** *Contact lenses, if worn, should be removed immediately if at all possible. Begin flushing even if contacts cannot be removed.*
- If the injured person is lying down, gently hold the eyelids open and pour water from the inner corner of the eye outward. **WARNING:** *Do NOT allow the chemical to run into the other eye.*
- 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.

## Safety Showers

- Begin use of the shower as soon as possible, removing any contaminated clothing while in the shower (have large towels or lab coats available for privacy).
- 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. Cool water is fine; it slows chemical reactions and is good first aid for burns.
- **WARNING:** *AVOID using neutralizing solutions unless recommended by medical personnel.*

**Fire Blankets** To use a fire blanket, follow the manufacturer's recommended technique of wrapping the victim to extinguish the fire. **WARNING:** *Incorrect use could hold heat near the body, increasing the possibility of burns.*

- For a folded fire blanket stored in a case, spread the blanket on the floor so that the affected person can wrap it around his or her body while rolling.
- For a fire blanket in a vertical wall case, the blanket will unroll from the case as the person wraps the blanket around his or her body. As soon as the blanket is out of the case, the person should lie on the floor to prevent a "chimney effect."

In both cases, hold the blanket tight at the neck to force flames away from the head.

**First-Aid Kits** Students should be aware of the location of the first-aid kit, but a teacher should be the one to administer first aid. Keep first-aid kits in a conspicuous place in the classroom or the laboratory. Mark this location clearly.

## Giving First Aid

First aid is the first assistance provided to a person suffering an accident or a sudden illness. Persons giving first aid should seek NOT to treat the victim but rather to protect him or her until professional medical assistance arrives. Every teacher bears the responsibility for knowing how to help a student in the case of an accident or illness.

It is strongly recommended that teachers take a first-aid course with CPR training. Some states require that at least some teachers in a school be formally trained in first aid. Check school regulations regarding the training of students in using emergency equipment, such as the safety showers and eyewash stations. **WARNING:** *Anyone administering first aid should wear protective gloves.*

This section provides general procedures for injuries most commonly related to school laboratory work. Most injuries are minor cuts and burns to the hands. Many injuries occur when students are cleaning glassware. In addition to the possibility of injury from broken glass, there is the threat of injury from the cleaning solution or the chemical substance used with the glassware.

## Cuts and Scratches

- Wash the injured area thoroughly.
- Place a compress on the wound to stop the flow of blood. **WARNING:** *Do NOT disturb blood clotting by removing saturated cloth, simply add more layers until bleeding slows or stops.*
- Replace a compress with a sterile bandage if the injury is minor. **WARNING:** *Do NOT use any topical medications unless advised to do so by a physician.*
- Accompany the student to the nurse's office if he or she has a moderate to severe injury.
- **WARNING:** *In case of severe cuts, do NOT use a tourniquet unless you are trained to do so and then only as a last resort.*
- Follow proper procedures to clean up blood.

## Seizures, Fainting Spells, Concussions, and Shock

- Leave the person lying down. Loosen any tight clothing and keep crowds away. Call the nurse immediately.
- Call for emergency medical aid immediately.
- Check for breathing and pulse immediately.
- Keep the injured person warm, quiet, and lying down. Elevate the feet a few inches if there are no chest or head injuries.
- Start CPR if necessary.

## Injuries from Chemical Spills

- Rush the injured person to the safety shower. Immediately drench the entire injured area with a continuous flow of water.
- Send a student to alert the school nurse or to get another teacher.
- Use a spill kit to contain and remove the chemicals.

## Eye Injuries from Foreign Substances

- Rush the student to the dual eyewash station. Remember to guide the student as he or she will have difficulty seeing.
- Rinse the open eyes with a continuous stream of water for 15 minutes.
- Send a student to alert the school nurse or another teacher.

## Exposure to Toxic Substances

- Rush the person to the nurse's office and call 911 or other emergency number. The person calling for medical assistance should know the victim's age and weight, the toxic substance involved, the amount taken, whether any first aid has been given, whether the victim has vomited, and how long it will take to get the victim to the hospital.
- The nurse should also contact the Poison Control Center immediately.
- If CPR is required, a mouth-to-mask resuscitator should be used to protect the person administering aid from being affected by the hazardous substance as well.
- **WARNING:** *Toxic substances can enter the body by inhalation, ingestion, injection, or skin contact.*

## Inhaled Poisons

- Call for medical assistance.
- Carry the victim to fresh air if possible. If the victim is too large to carry, open all doors and windows.
- Begin CPR if the victim is not breathing, but only if you are trained to do so. **WARNING:** *Do NOT inhale victim's breath.*
- Treat the victim for shock until medical assistance arrives.

## Ingested Poisons

- Consult the MSDS filed in your department.
- Call for medical assistance.
- Maintain the victim's breathing.
- **WARNING:** *Do NOT administer syrup of ipecac to induce vomiting, or water or milk for dilution of the poison, unless advised to do so by a physician or the Poison Control Center.*
- Take the container of poison to the medical facility.

## Skin Contact Poisons

- Remove contaminated clothing as soon as possible if contact is made with a plant poison (such as poison ivy oils). Wear rubber gloves if you are helping a student. Immediately wash all exposed areas with large quantities of soap and water.
- See section regarding the treatment of chemical burns of the skin and eyes.

**Chemical Burns** If the chemical is a strong corrosive, irritant, or is toxic, immediately send for an ambulance so that first aid will not have to be discontinued during transport to medical attention. This is especially important for strong alkali (such as sodium hydroxide) burns.

- Use rubber gloves to remove victim's clothing.
- As quickly as possible, place the student in the safety shower for at least 15 minutes.
- Call the nurse and 911.
- **WARNING:** *Do NOT attempt to neutralize the chemical unless approved by medical personnel and the chemical is first diluted with water.*
- Wash chemical burns to the eyes, eyelids, and face at the eyewash station for at least 15 minutes.
- Remove contact lenses if at all possible.
- Cover burns with a sterile dressing (NOT fluff cotton).

**Thermal (Heat) Burns** Identify the severity (whether first-, second-, or third-degree) of the injury to the body and follow the appropriate first-aid procedure.

**First-Degree Burns** These are the least severe burns, affecting the outer layer of the epidermis only. They are characterized by redness and heat and commonly cause itching, burning, and pain in the victim.

- Hold burn under cool running water for 5 minutes.
- Cover burn with a clean dressing.

Second-Degree Burns These burns affect deeper layers of the epidermis. They are characterized by mottled red skin and blisters. Second-degree burns cause considerable pain and the loss of bodily fluids through blisters. The victim is at risk for infection and might require hospitalization.

- Lay clean towels over the burned areas and pour cool water over the towels. **WARNING:** *Do NOT add ice or salt to the water.*
- Gently blot the area dry. **WARNING:** *Do NOT break blisters, remove tissue, or apply ointments, sprays, or salves.*
- Cover the burned area with a clean, dry dressing.
- **WARNING:** *If legs are affected, keep them elevated.*

**Third-Degree Burns** These are the most severe burns, affecting skin as well as deeper tissue. Third-degree burns appear white or charred and cause little pain due to the damage caused to nerve endings. The victim may lose internal fluids and is at high risk for infection, and usually will require extensive hospitalization.

- Call 911 or other emergency number.
- Call the school nurse.

- Treat for shock.
- **WARNING:** *Do NOT remove burnt clothing.*
- **WARNING:** *Do NOT cover burns with dressing.*

## Bites and Stings

- Wear gloves while attending bites. **WARNING:** *There is danger of infections and rabies from bites of all warm-blooded animals.*
- Identify the source of the bite or sting.
- If the bite or sting is from a venomous source, seek medical help immediately.
- Keep the victim calm and quiet. Keep injury area lower than the heart. **WARNING:** *Do NOT apply ice.*

**Venomous Snake Bites WARNING:** *Do NOT administer treatment unless a hospital is more than one hour away. If it is, then apply constricting bands. Check pulse to be sure blood flow has not stopped.*

- **WARNING:** *Incision and suction are NOT recommended.*
- If you have a field trip planned for an area where snakebite is possible and medical help will not be nearby, have a snakebite kit available and obtain training in its use.

**Tick Bites** Ticks should only be removed by parents or guardians. Contact them as soon as possible, and advise them to seek medical help, especially if the victim becomes ill within a week of the bite.

## In Case of Allergic Reactions

- Get immediate medical help if the victim has a history of allergies.
  Keep the victim as quiet as possible.
- Use cold compresses (or ice wrapped in a cloth) to relieve swelling.
- If the allergic reaction was the result of an insect sting, remove the stinger with a scraping motion using a stiff card or fingernail to reduce toxin injection. **WARNING:** *Do NOT pull the stinger out.*
- Wash the bite area with soap and water. Apply calamine lotion (or a paste of water and baking soda).
- Treat for shock if the allergic reaction is severe.
- **WARNING:** *Any sting to the throat, mouth, or tongue requires medical help immediately.*

## Human Bites

- Immediately notify parents/guardians of both parties. Medical records should be shared.
- Wash bite area with soap and water. Get medical treatment if the skin is broken.

## Cleaning Up Hazardous Spills

**Mercury WARNING:** *Mercury thermometers are NOT recommended. If you still use them, and they break, use the following steps to clean up the spills. These are general guidelines for cleaning up a mercury spill. You should also be aware of state and local regulations that apply in*

*case a thermometer breaks and its mercury spills. You should ask students to leave the area of the spill before you begin your clean-up.*

- A mercury sponge, which contains zinc fibers, is useful for final mercury cleanup. Wipe down all surrounding areas, as mercury tends to splatter.
- If preferred, the mercury may be sprinkled with zinc metal dust to form an amalgam which is more easily collected than elemental mercury. **WARNING:** *Take great care with zinc metal dust, as it expands when damp and can cause a container to explode.*
- If a commercial spill kit is not available,
  - On a hard surface, while you're wearing gloves, either use a stiff paper to brush the beads together or use a dropper to collect the beads. **WARNING:** *Do NOT sweep the mercury with a broom, as this creates more vapors and contaminates the broom*. Put all parts—the broken thermometer, the paper or dropper, and the beads of mercury—in a seamless polyethylene or polypropylene bottle or widemouthed jar for regulated disposal. Seal the container and place it in the toxic/caustic waste bin for proper disposal.
  - On a carpet, cut out and dispose of the mercury spill in a toxic/caustic container. **WARNING:** *Do NOT vacuum the mercury because it will cause the mercury to evaporate and become part of the atmosphere. Incinerating mercury also will cause it to become part of the atmosphere.*
- When you replace mercury thermometers with digital ones, dispose of the mercury thermometers as you would a mercury spill.

**Other Chemical Spills** If a chemical spill occurs in the laboratory or in the classroom, quick action by the teacher can reduce the possibility of injury to a student or the teacher. A chemical spill such as a liter bottle of hydrochloric acid breaking in the chemistry laboratory is considered a major spill.

- Immediately evacuate all students through the exits farthest from the spill. Fumes from a chemical spill can cause severe damage to the body.
- Turn on the emergency exhaust fan.
- Contain the spill wearing the proper protective clothing. **WARNING:** *Do NOT allow the spill to trap you.*
- Call for help. The school safety plan should contain the numbers of agencies or departments in your community that will assist in containment and removal of the chemical.

**Biological Spills** Biological spills that occur in a science laboratory or classroom can generate aerosols that can be dispersed in the air throughout the room. These spills can be very dangerous if they involve microorganisms that may be infectious. Any biological material, living or dead, that is a pathogen or disease-carrying organism is termed a biohazard. The biohazard symbol is universal and should be used on all potential pathogenic material. Any bodily fluids spattered during an accident or as a result of illness should be considered potentially infected. **WARNING:** *Blood spills should be cleaned by persons trained in the task. If an untrained person encounters a blood spill they should limit access to the area and call for assistance immediately.*

- **WARNING:** *AVOID direct skin contact with bodily fluids.*
- Use disposable gloves when direct hand contact with bodily fluids is necessary.
- Keep gloves in accessible locations.
- Wear mask and eye protection or face shield.
- Wear lab aprons or coats.
- Remove any contaminated clothing.
- Vigorously wash the exposed area with soap and water for one minute.
- Soak up the spill with paper towels.
- Place contaminated paper towels in a plastic bag for disposal. According to the Centers for Disease Control, infective waste should be either incinerated or autoclaved before disposal in a sanitary landfill. A school janitor should be familiar with the procedure for your district.
- Place sharp items such as needles and scalpel blades in a red biohazard container made especially for sharp objects.
- Glassware and microscope slides can be sterilized and reused.
- Clean any surface that has been in contact with the fluids with an EPA-approved disinfectant such as a freshly made 1:10 dilution of household bleach.
- After removing gloves, wash hands for 10 to 15 seconds with a disinfectant soap and running water.

## Why Use Electronic Data Collection?

Electronic data-collection technology, or probeware, can greatly enhance learning experiences in the science classroom. This is not to say that stopwatches, metersticks, and spring scales no longer have a place in the classroom. Teaching students to use traditional measuring instruments is still important; however, teaching students to use probeware in our technology-filled world has become just as important. Below are some of the advantages electronic data collection can bring to the science classroom.

Probeware

- expedites data collection allowing students to spend more time analyzing results;
- provides more accurate readings and reduces student measurement errors when compared to traditional measuring instruments;
- allows students to perform experiments with instruments not previously obtainable in the classroom. Instruments include motion detectors, CO2 gas sensors, accelerometers, and EKG sensors;
- permits students to continuously monitor experiments without requiring close attention. For example, a student may want to monitor CO2 production from a plant over a 24-hour period;
- helps students directly measure values that were more indirectly measured in the past. For example, traditional experiments investigating the pressure/volume relationship in gases required students to infer the pressure from the amount of weight on a syringe. Using a gas pressure sensor, students can measure the pressure directly.

In addition, the use of probeware supports the shift from conventional teacher/student dialogue and teacher-centered instruction to a learning environment that is student-centered and inquiry-based.

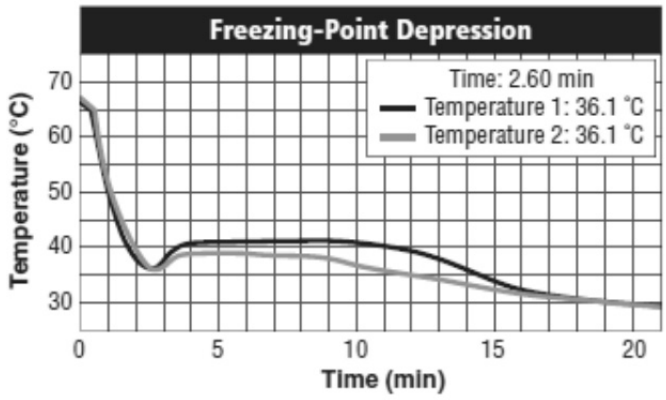
According to the National Science Teachers Association (NSTA), technology should permit students to collect and analyze data as scientists do. Research shows that the use of probe ware has a positive impact on student learning and achievement from elementary grades through college across all science disciplines. National organizations including NSTA, ISTE, ASTE, and IB call for the regular incorporation of technology, including probe ware, in the science classroom. The National Education Technology Standards specifically recommend the use of scientific probe ware with students when conducting real-time investigations of natural scientific phenomena.

# Data Collection Hardware and Software

Although there are many electronic data-collection systems available, each system consists of four basic components—the computing platform, the data-collection software, the sensor interface, and the sensors. The newest systems combine these components, reducing the number of system pieces.

## Computing Platform

The main component of a data-collection system is the computing platform. The computing platform can be a computer, a handheld computing device, or a graphing calculator.




## Data-Collection Software

The data-collection software provides control over the system. The software provides a way to monitor sensor readings, set datacollection parameters, initiate data collection, represent data graphically and numerically, and analyze data.

## Sensor Interface

The sensor interface is a bridge between sensors and the computing platform. The main function of the interface is to control the data collection by providing power to the sensors, transferring sensor identification information to the data collection software, applying the data collection settings, and transferring the sensor readings to the data-collection software.

## Sensors

Electronic sensors respond to changes in environmental conditions related to the physical attribute they are measuring. Many sensors include an integrated circuit chip that stores sensor identification and calibration information.

## USB and Wireless Sensors

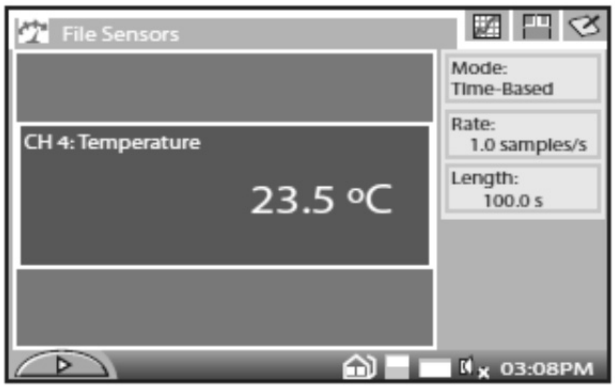
USB and wireless sensors have the sensor interface built into the sensor. These sensors connect directly to the computing platform or communicate with the platform wirelessly.

## Stand-Alone Data Collection Systems

The newest data collection systems are all-inone handhelds that include the computing platform, data collection software, and sensor interface. Many of these systems also include built-in sensors. While these systems have their own computing platforms, many can also be used with a computer.

## Collect Data Using Probeware

Electronic data collection starts by connecting your data-collection system components together and launching the data collection software.




## Setting Up Data Collection

For most data-collection systems, connecting a sensor is enough to enable you to collect data. Default data-collection settings based on the connected sensor(s) are set in the software. For example, a temperature probe might default to reporting temperatures in degrees Celsius and collecting data for 180 seconds. You can use the default settings or modify them to fit your experiment.

## Sensor Settings

The sensor's displayed unit of measurement is the most commonly changed sensor setting. Other sensor setting options include zeroing and sensor calibration.

## Data Collection Mode: Time-Based

The most frequently used data-collection mode is time-based. Use this mode for experiments where changes in the experimental variables occur over time. The settings associated with time-based data collection are described below.

- **Sample Rate** The number of data points collected each second. For some systems, the sample rate is entered as the time between samples. Acceptable sample rates depend on the sensor used and the sensor interface.
- **Number of Samples** The number of data points collected for each connected sensor. Depending on the data collection software, this value is either entered directly or is calculated based on the sample rate and experiment length. The maximum number of samples allowed depends on the available memory on your system.
- **Experiment Length** The time the system will be collecting data. Depending on the data collection software, this value is either entered directly or is calculated based on the sample rate and number of samples.

  **Example:** Consider the experiment in which you investigate changes in the temperature of 100 mL of room-temperature distilled water after adding an effervescent antacid tablet. Preliminary experimentation indicates that the reaction stops after two minutes. For this experiment, the time-based data collection settings could be:

  **Sample Rate** = 2 samples/second (0.5 seconds between samples)

  **Number of Samples** = 300

  **Experiment Length** = 150 seconds (2.5 minutes)

### Data Collection Mode: Event-Based

Another data collection mode is event-based data collection. Event-based data collection allows you to manually control when each sample is collected. The sensor value reported is typically a single sensor reading but could be an average of several readings taken over time. The independent variable, representing the event, is entered manually, or it can be sequentially generated.

**Example:** Consider the experiment in which you want to investigate the pressure of a confined gas as it relates to the volume of the container. In this case, it is desirable to collect pressure measurements only after adjusting the container's volume. Since the changes in volume will not necessarily occur at equal time intervals, event-based data collection is used.

### Collect the Data

Once the setup is complete, you are ready to collect data. Start data collection by interacting with the "Collect" or "Play" button or icon. Advanced start options such as triggering are available with some systems. Refer to your software documentation for details. A graph of the data is displayed during data collection.

### Analyze the Data

You can analyze the collected data in many different ways. For many experiments, reading the information directly from the graph is enough. Other experiments require additional calculations, graph modifications, or modeling to interpret the data.

## Tips for Successful Data Collection

The following are some tips that can help you use probeware successfully in your class.

### Keep your system up-to-date.

To ensure you have the latest features and functionality available for your data-collection system, keep your data collection software up-to-date.

### Know your sensors.

Here are some important things to know about the sensors you are using.

- **Sensor range:** the minimum and maximum values the sensor can measure
- **Response time:** the time it takes the sensor reading to show accurate measurements given a change in the measured quantity
- **Warm-up period:** the length of time a sensor must be powered before it will give accurate measurements
- **Damaging conditions:** conditions that would cause permanent damage to a sensor
- **Storage requirements:** conditions under which a sensor should be stored to ensure maximum life

## Try it before you assign it.

This is especially important for anyone who is new to electronic data collection. Doing the experiment will help you identify places where students may encounter difficulty. Helping students avoid problems keeps the focus on the science and not the technology.

## Troubleshooting

If you think that the probeware is in error, test the system in a more controlled way. For example, if you doubt the readings from a voltage sensor, connect it across a known DC source, such as a single AA battery. If it properly reads the voltage here, it is probably working in your experiment.