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ABSTRACT

This publication is intended to be a resource for teachers and administrators who are responsible for the safety of students, and others, in the general areas where science instructing is occurring. The handbook is designed to assist teachers of science regardless of their background in science. Particular concerns such as laboratory safety procedures, chemical disposal, poisonous plants, and the use of radioactive sources in the classroom are among topics discussed. A bibliography lists additional reference material on science safety available in journals and from state and federal education agencies. (Author/CP)

SAFETY FIRST IN SCIENCE TEACHING

DIVISION OF SCIENCE
NORTH CAROLINA DEPARTMENT OF PUBLIC INSTRUCTION

Emergency Information

	Phone No.
Rescue Squad	______________
Fire	______________
Police	______________
Hospital	______________
Duke Poison Control Center*	(919) 684-8111

*The Duke Poison Control Center is open 24 hours/day. Its purpose is to advise physicians and individuals on procedures and treatment relating to any type of poisoning.

If further assistance is needed in any area of safety, contact:

Division of Science Education
State Department of Public Instruction
Raleigh, NC 27611
(919) 733-3694

Foreword

Safety should be FIRST in the minds of teachers at all levels, K-12. Some of the most hazardous conditions exist where science is taught, in the classroom and out-of-doors, ranging from explosive materials to poisonous plants and animals. Safety instruction should become an integral part of the science program. With the mainstreaming of handicapped students into regular classes on the increase, and courts becoming more sensitive to the well-being of the individual, school personnel must accept the safety of each student as one of their major responsibilities.

Each teacher of science must be aware of the potential hazard(s) which may be associated with any science endeavor approached by the student. That teacher must also know appropriate steps to take in case of an accident or emergency. The principal should insist that teachers practice safety FIRST in science classes at all levels.

All schools are encouraged to develop a safety program for science teachers if one does not exist. Such a program should include plans for staff in-service and written safety regulations to be followed by all for whom the program is developed. This publication, prepared by the Division of Science Education, is provided to every school in the state for use by schools and local administrative units in developing programs of their own, designed to meet specific needs.

Users of this publication are encouraged to suggest ways to improve it.

A. Craig Phillips

April 1977 State Superintendent of Public Instruction

Introduction

This publication is a resource for teachers and administrators who are responsible for the safety of students and others when they (students and others) are in the general area(s) where science instruction is occurring. It is by no means all-inclusive. In many cases, references are given to other sources that give detailed coverage to individual or multiple topics. The publication should be of special assistance to teachers at all levels, grades K-12.

This publication is designed to assist teachers of science regardless of their background in science. An attempt was made to include topics thought to be essential and pertinent to the various types of science or science-related courses offered in the elementary and secondary schools of the state.

With increased federal, state, and local emphasis being placed on safety, it is imperative that more emphasis be placed on the safety aspects of science instruction. Unless safety precautions are taken to protect the student and others during the performance of certain science activities, science programs could, conceivably, eventually suffer from the banning of certain effective activities considered too dangerous to be performed in available settings in or around our schools. The Occupational Safety and Health Act (OSHA), passed by Congress in 1970, has implications for stricter safety standards in connection with science programs in the schools. OSHA is addressed at various places in this publication. Schools and school units are encouraged to use the contents of this publication as a basis for developing their own comprehensive safety programs. Many of the sources referenced in it can serve to enhance any local safety program.

For assistance in regard to planning and conducting safety staff development activities and designing comprehensive safety programs, contact the Division of Science Education, State Department of Public Instruction, Raleigh, NC 27611. A number of safety publications are retained in the office of the Division of Science Education and may be reviewed by interested persons.

Contents

Safety and the Science Program

Any modern science program has a responsibility for teaching students about the nature of the scientific enterprise. Students have a right to learn how to think scientifically and solve problems through the active use of science processes. Students should have ample opportunities to engage in scientific work through laboratory or other "hands-on" activities. These concrete experiences are necessary for prime results at the elementary and advanced levels of science learning. With the trend of science education toward more activity-oriented work and more involvement of students in the processes of science, it is essential to develop a positive approach to laboratory safety. Safety should be an integral part of the planning, preparation, and implementation of any science program.

An experiential science program possesses certain potential dangers. Yet, with careful planning, most potential dangers can be coped with safely in an activity-oriented science program. The responsibility for safety and the enforcement of safety regulations and laws in the science classroom and laboratory is that of the principal, teacher, and student--each assuming his/her share. Carelessness and a negative or apathetic attitude toward safety are the major causes of accidents.

According to the National Safety Council, about 32,000 school-related accidents occur each school year; about 5,000 of these are science-related. Junior high grades 7-9 experience the highest frequency of accidents while elementary grades report the lowest accident frequency. Another source[1] estimates one major accident per 40 students per year in laboratory settings throughout the country.

A 1970 study[2] on high school science safety revealed the following:

- Advanced placement groups have the most accidents.
- Class enrollment and laboratory space have a significant relationship to laboratory accidents; the higher the classroom enrollment

[1] George J. O'Neill, Television Series Program #1, Safety in the Science Laboratory. Sponsored by the N. E. Tennessee Section of the American Chemical Society in cooperation with WSJK, Knoxville, TN, 1975.

[2] John Wesley Brennan, "An Investigation of Factors Related to Safety in the High School Science Program." Ed.D dissertation, University of Denver, 1970. (ED 085 179).

and the smaller the laboratory space, the higher the frequency of accidents.

- Fewer accidents occur when individual laboratory stations exist.
- The chemistry class is more prone than other classes to laboratory accidents.

The prevention of accidents can be accomplished through a positive science safety educational program which places emphasis on teacher and student awareness of the potential dangers in science-related activities. "SAFETY FIRST" should be the basic motto for the school science program. However, safety considerations should seldom rule out a science lesson. Effective planning can sometimes be used to capitalize on safety problems. Developing and maintaining positive attitudes toward safety require continual efforts in safety education. Hopefully, safety training in the science program will instill in the student the importance of safety in all areas of work and play.

Safety and Law

The principal is responsible for the overall supervision of the safety program in the school. Likewise, the science teacher is responsible for the supervision of safety in the science class.

Individual teachers can be held liable for negligent acts resulting in personal injury to students. Some school boards have liability coverage which might support teachers if legal action is brought against them. Teachers should inquire about the nature of local board coverage and/or their own personal liability coverage. The extent of a teacher's liability is discussed in the NSTA publication, Science Teaching and the Law, by W. Brown (see Bibliography).

The Public School Laws of North Carolina specifically deal with required safety devices for eye protection. Article 33, "Safety Devices Required," Section 115, Part 258 through Part 260.1 is quoted below:

Statute #115-258. Eye protection devices required in certain courses.

The governing board or authority of any public or private school or educational institution within the State, wherein shops or laboratories are conducted providing instructional or experimental programs involving:

1. hot solids, liquids or molten metals; or
2. milling, sawing, turning, shaping, cutting, or stamping of any solid materials; or

3. heat treatment, tempering, or kiln firing of any metal or other materials; or
4. gas or electric arc welding; or
5. repair or servicing of any vehicle; or
6. [c]austic or explosive chemicals or materials,

shall provide for and require that every student and teacher wear industrial quality eye protective devices at all times while participating in any such program. These industrial quality eye protective devices shall be furnished free of charge to the student and teacher.

Statute #115-259. Visitors to wear eye safety devices.

Visitors to such shops and laboratories shall be furnished with and required to wear such eye safety devices while such programs are in progress.

Statute #115-260. "Industrial quality eye protective devices" defined.

"Industrial quality eye protective devices," as used in Section 115-258 means devices meeting the standards of the U.S.A. Standard Practice for Occupational and Educational Eye and Face Protection, Z 87.1-1968 approved by the U.S.A. Standards Institute, Inc.

Statute #115-260.1. "Corrective-protective" devices.

In those cases where "corrective-protective" devices that require prescription ophthalmic lenses are necessary, such devices shall only be supplied by those persons licensed by the State to prescribe or supply "corrective-protective" devices.

The Occupational Safety and Health Act of North Carolina (N. C. OSHA) General Statute 95-126-155, provides for the safety and health of employees, both in the public and private sector of the state. The Act also provides for the administration and enforcement in conformity with plans entered into between the state and the federal government.

The N. C. OSHA can and will affect science teaching. In general, the law addresses topics such as: eye and body protection, storage facilities, compressed gases, first-aid supplies, flammable or combustible liquids, respiratory protection, air contaminants, fire protection, waste cans, safety color codes for marking physical hazards, and radiation hazards. The coverage is too extensive to address in this publication. Inquiries should be addressed directly to the N. C. Department of Labor, Occupational Safety and Health Division, P. O. Box 27407, Raleigh, NC 27611.

Recommendations

The following recommendations are made in an effort to promote safety in science teaching on a statewide basis:

- Local Education Agencies should have a clear, written statement of safety policy and be supported with manuals, procedures, instructions, signs, etc., wherever potential hazards may exist.

- Local Education Agencies should maintain adequate school accident records to permit continued appraisal of safety performance.[1]

- Prompt administrative action should be taken to correct unsafe conditions and practices.

- Understanding of the principles of safety and of the specific requirements of various activities should be acquired by teachers and students.

- Each science department head or principal should be responsible for the science safety program, with the total program being coordinated at the central administrative level.

- An annual review should be made of the science safety program.

- Staff development or in-service programs containing a first-aid component[2] should be provided for all science teachers. (Assistance in first-aid training can be obtained from the local Red Cross.)

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[1]For information on forms for standard reporting of student accidents, write to the National Safety Council, 444 N. Michigan Avenue, Chicago, IL 60611.

[2]Two films, "Science Safety Lab - Part I and Part 2," are available and can be scheduled through Media Support Services, Division of Educational Media, Department of Public Instruction, Raleigh, NC 27611.

Laboratory Safety Procedures

Established safety procedures are essential to any effective safety program. Recommended procedures must be understood and practiced by teachers and students if accidents are to be minimized. The procedures listed in this section cover major areas in science teaching; however, these procedures are not "absolutes" and should be interpreted with reason.

Guidelines

These guidelines can be used as an effective checklist for evaluating the science safety program.

General

- Always perform an experiment or demonstration prior to allowing students to replicate the activity. Look for possible hazards. Alert students to potential dangers. Safety instructions should be given each time an experiment is begun.
- Horseplay or practical jokes of any kind are not to be tolerated.
- Never eat or drink in the laboratory or from laboratory equipment.
- Students should perform no unauthorized experiments.
- Exercise great care in noting odors or fumes. Use a waffing motion of the hand.
- Never use mouth suction in filling pipettes with chemical reagents. (Use a suction bulb.)
- Never "force" glass tubing into rubber stoppers.
- Use heat-safety items such as safety tongs, asbestos mittens, aprons, rubber gloves.
- Constant surveillance and supervision of student activities are essential.
- Student attitude toward safety is imperative. Students should not fear doing experiments, using reagents, or equipment, but should respect them for potential hazards.
- Teachers should set good safety examples when conducting demonstrations and experiments.

- Experiments should never be assumed to be free of safety hazards just because they are printed.

Laboratory Safety

- Good housekeeping is essential in maintaining safe laboratory conditions.

- Confine long hair and loose clothing. Laboratory aprons should be worn.

- Never conduct experiments in the labor[illegible]one.

- Use safety shields or screens whenever there is potential danger that an explosion or implosion of apparatus might occur.

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

- Make certain all hot plates and open burners are turned off when leaving the laboratory.

- Frequent inspection of the laboratory should be conducted.

- Fire blanket(s) and fully operable fire extinguisher(s) should be located in each laboratory.

- Chemistry laboratories should contain an emergency shower, eyewash fountain, and safety goggles for all students and teacher(s).

- Every laboratory should have two unobstructed exits.

- There should be an annual, verified safety check of each laboratory.

- One teacher should not have to supervise more than 24 students engaged in laboratory activities at any one time.[1]

- All work surfaces in the chemical or biological laboratory should be thoroughly cleaned after each use.

- Chemistry laboratories should be equipped with functional fume hoods. Fume hoods should be available for any activity(ies) involving flammable or toxic substances.

- Master cutoff valves or switches are advisable for laboratories with gas, water, and electricity.

- Students enrolled in laboratory science programs should be encouraged to join the school insurance plan if available.

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[1] Conditions for Good Science Teaching in Secondary Schools, National Science Teachers Association, 1742 Connecticut Avenue, N. W., Washington, DC 20009, 1970, p. 4.

First-Aid and Emergency Tips

- Have first-aid procedures established in the event of an accident.
- All students and teachers should know the location of fire extinguishers, eyewash fountains, safety showers, fire blankets, and first-aid kits.
- Safety signs should identify the location of safety equipment.
- Student aides should be fully aware of potential hazards and know how to deal with accidents.
- Emergency instructions concerning fire, explosions, chemical reactions, spillage, and first-aid procedures should be conspicuously posted near all storage areas.
- Safety posters are encouraged in science laboratories.

Biological

- Never use a scalpel or cutting device with more than one cutting edge.
- Specimens should be properly supported when being dissected. Never dissect a handheld specimen.
- Only nonpathogenic bacteria should be used in the classroom. Indiscriminate culturing and handling of pathogenic or nonpathogenic organisms are discouraged.
- Petri dish cultures should be sealed with tape.
- Bacterial cultures should be killed before washing petri dishes. Most cultures can be killed by heating for 20 minutes at 15 pounds/inch^2 (138 kPa) of pressure.
- Contaminated culture media should be sterilized with a strong disinfectant and washed with a strong cleaning agent.
- Always flame wire loops prior to and after transferring microorganisms.
- Wear proper equipment (apron and rubber gloves) when washing bacteriological or chemical ware.
- Use utmost caution when using a pressure cooker. Turn off the heat source, remove the cooker, and allow the pressure to gradually reduce to normal atmospheric pressure prior to removing the cover.
- Never transfer liquid media or other solutions with a mouth pipette.
- Use proper illumination for microscopes. Reflected sunlight can damage the eye.

- Under no condition should potassium cyanide be used as the killing agent in insect-killing jars. If alcohol, chloroform, or ether is used as the killing agent, students should be warned of their flammability and toxicity.

- Utmost precautions should be used to ensure that only sterile, disposable lancets are used if blood samples are taken. Proper supervision is essential. Mechanical lancets should not be used for blood typing.

Physical

- Proper protective devices (eyes, body) should be used when hammering, chipping, or grinding rocks, minerals, or metals.

- Direct viewing of the sun should be avoided at all times.

- Direct viewing of infrared and ultraviolet light sources should be avoided at all times.

- Never allow the open end of a heated test tube to be pointed toward anyone.

- When alcohol is heated, it must be in a water bath container with the top of the beaker, etc., holding the alcohol below the top of the water bath container.

- Volatile liquids such as ether, gasoline, alcohol, carbon sulfide, and benzene should be used in very small quantities away from open flames and in a well-ventilated room. Such substances should be heated electrically or in water baths.

- Broken or chipped glassware should not be used.

- Breathing gases, especially in high concentrations, can be very dangerous. Carbon dioxide is no exception, as unconsciousness can result within seconds if high concentrations are breathed. Breathing pure nitrogen, argon, helium, or hydrogen is dangerous.

- Chemicals should not be tasted for identification purposes.

- When heating materials in glassware by means of a gas flame, the glassware should be protected from direct contact with the flame through use of a wire gauze or asbestos-centered wire gauze.

- Don't pour water into acid. (DO WHAT YOU "OUGHTA" (ought to), PUT THE ACID IN THE <u>WATER</u>!)

- Broken glass in sinks should be promptly removed as it presents a serious hazard.

- Use a fume hood whenever dealing with highly volatile, toxic fumes.

- When working with flammable liquids:
  - Have a CO_2 or multipurpose fire extinguisher available.
  - Work in a well-ventilated area.
  - Keep the liquid over a pan or sink.
  - Use no flames or high-temperature heating devices.
  - Do not store in a home-type refrigerator. Fumes may be ignited by sparks produced in the electrical switching system. (Explosion-proof refrigerators are available from science supply houses.)

Electrical

- Students should understand that the human body is a conductor of electricity.
- Batteries or cells of 1.5 volts or less are safe for elementary classroom use. However, the battery may explode if heated or thrown into an open fire. The chemicals inside of the battery can be dangerous if taken internally or exposed to the skin.
- The use of high voltage AC such as a 110-volt line can be extremely dangerous.
- Students should be taught safety precautions regarding the use of electricity in everyday situations.
- Students should be cautioned not to "experiment" with electric current on home or school circuits.
- Work areas, including floors and counters, should be dry.
- Never handle electrical equipment with wet hands or when standing in damp areas.
- Never overload circuits.
- To prevent severe shocks, discharge electrical condensers and Leyden jars before handling.
- Water and gas pipes are grounded. Never touch a ground, such as water and gas pipes and an electrical circuit simultaneously.
- Do not use electrical wires with worn insulation.
- Use 3-prong service outlets.
- Electrical equipment should be properly grounded. A ground-fault circuit breaker is desirable for all laboratory AC circuits. A master switch to cut off electricity to all stations is desirable for all laboratory AC circuits.

Safety Equipment

In accordance with North Carolina laws and regulations, all laboratories and science teaching areas should have, and use, safety equipment appropriate for the type of science activity being conducted. Protective equipment is designed to prevent or minimize injury. It does not prevent accidents from occurring.

The following is a list of needed safety items in the science laboratory:

- fire extinguishers*
- first-aid kits
- fire blankets
- sand buckets
- eyewash facilities
- emergency shower facilities
- safety goggles
- laboratory aprons
- gloves (asbestos, etc.)
- tongs
- respirators
- wire gauze and/or asbestos-centered wire gauze.

*The multipurpose ABC-type dry chemical fire extinguisher covers all fire classes except for reactive and combustible metals such as sodium, lithium, potassium, magnesium, and certain metallic hydrides and alkyds. Below are fire classes defined:

- Class "A"--Fires in wood, textiles, and other ordinary combustibles containing carbonaceous material. This type of fire is extinguished by cooling with water or a solution containing water (loaded stream) which wets down material and prevents glowing embers from rekindling. A general purpose dry chemical extinguisher is also effective by fusing and insulating.
- Class "B"--Fires in gasoline, oil, grease, paint, or other liquids that gasify when heated. This type of fire is extinguished by smothering, thus shutting off the air supply. Carbon dioxide, dry chemical, and foam are effective on this type of fire.
- Class "C"--Fires in live electrical equipment. This type of fire is extinguished by using a nonconducting agent. A carbon dioxide extinguisher smothers the flame without damaging the equipment. A dry chemical extinguisher is also effective. Whenever possible, the source of power to the burning equipment should be cut off.
- Class "D"--This new and somewhat specialized classification includes fires in combustible metals such as magnesium, titanium, zirconium, sodium, potassium, and others. A special extinguisher powder, unlike

regular dry chemical and general purpose dry chemical, may be applied by scoop. Dry sand may also be used to extinguish small class "D" fires. Apply by scoop.

Storage Facilities

Proper storage policies are essential to the safe operation of any laboratory. Below are some precautions which should be taken into consideration:

- Laboratory chemicals and equipment should not be stored in the same room.
- Storage rooms containing flammable, toxic, or combustible substances should be properly ventilated.
- The chemical storage area should be secured at all times when not in use, with access only to authorized personnel.
- Flammables and dangerous chemicals should be locked in a fire-resistant cabinet.
- Flammable or toxic gases should be stored at or above ground level and not in basements.
- All gas cylinders should be secured against falling over and should be stored away from heat sources.
- All chemicals should be adequately labeled and stored alphabetically according to types.
- A fire extinguisher should be immediately accessible. (The multi-purpose-type covers class A, B, and C fires.)
- Mixing or transferring chemicals should not be permitted in the storage area.
- Storage areas should not have blind alleys.
- Open flame, smoking, or any other type of heat should not be permitted in the chemical storage area(s).
- Cleanliness and order should be maintained in the storage area at all times.
- Chemical storage areas should be well-ventilated and lighted.

Safety with Glassware

A high percentage of laboratory cuts and burns are due to handling glassware. Students should be properly instructed on the use and care of glassware prior to laboratory work.[1] The precautions listed below should be followed when working with glassware in the laboratory:

- Glassware which is to be heated should be Pyrex or a similar heat-treated-type.
- Broken glassware should be disposed of in a special container marked "BROKEN GLASS."
- Fingers should never be used to pick up broken glass. A whisk broom and dustpan can be used for large pieces, and large pieces of wet cotton can be used for very small pieces.
- Glassware should be thoroughly cleaned after use.
- Students should never eat or drink from laboratory glassware.
- Glass objects which present breakage hazards should be wrapped with plastic wire, wire screening, tape, or other special devices. Examples: taped Dewar flask, safety rings on graduated cylinders.
- Heated glassware looks cool several seconds after heating, but can still burn for several minutes.

Glass Tubing Safety

Glass tubing is a versatile item in the science classroom. However, if not handled carefully, it can produce severe cuts. The following procedures are described to reduce the dangers and help increase the versatility of this common laboratory item.

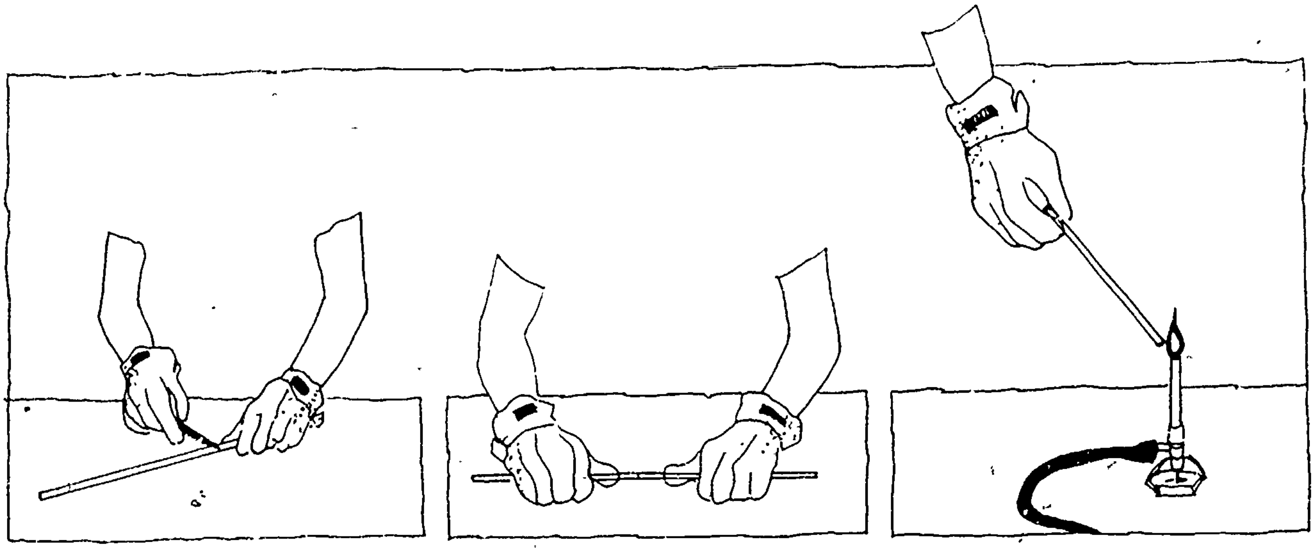
Cutting

Glass tubing is usually purchased in long segments. The following steps are provided to assist in cutting pieces to required lengths:

1. Lay the tubing on a flat surface and hold it firmly in place with hand at the approximate position where the break is to be made.
2. At the position where the cut is desired, produce a deep scratch by drawing the edge of a triangular file firmly across the tube.
3. If gloves are not available, use a cloth to cover the tube in the area in which the break is to be made.
4. Grasp the covered tube with both hands so that the scratch is on the outer side, the fingers circling the tube, with the thumbs meeting on the opposite side behind the scratch.

[1] An excellent article on handling glassware appears in The Science Teacher, January 1967, pp. 66-68.

5. Snap the tube sharply by pushing outward with the thumbs and simultaneously pulling back with the fingers. The tube will break on the scratch mark.



Fire Polishing

The ends of a glass tube may have very sharp edges. These edges can be smoothed by fire polishing. Below are steps to follow when fire polishing a glass tube:

1. Hold the glass tube so that the sharp end is in the top of the flame of a gas burner.

2. Rotate the tube so all sides are heated evenly, causing the sharp edges to melt and become smooth.

3. Place the fire-polished tube on an asbestos mat or some other insulation material while it cools.

Bending

Bending glass tubing is often necessary in order to carry out science experiments. The following procedures are recommended for producing needed configurations:

1. Place a wing top attachment on a gas burner and ignite the burner.

2. Heat the area of the glass tube to be bent while holding it with one hand on each end.

3. While heating the tube, rotate it constantly in your fingers to ensure even heating on all sides.

4. When the glass becomes soft and pliable, remove it from the flame and quickly bend the tube to the desired shape. Results usually improve with practice.

5. Place the hot glass tube on an asbestos mat or some other insulation material while it cools.

Inserting Glass Tubing/Rods

Inserting glass tubing or rods into cork or rubber stoppers can be very dangerous. The following steps should be followed to prevent injuries:

1. All glass tubing used with cork or rubber stoppers should be fire polished or have the edges beveled with emery paper.

2. A soap solution or glycerine should be used on the ends of glass rods or tubing for lubrication before inserting them into a stopper. The rod or tubing should be wrapped with several layers of cloth. They should be held as close as possible to the stopper. Always aim the rod or tubing away from the palm of the hand which holds the stopper.

3. Cork stoppers should be removed from tubing to keep them from adhering and "freezing." "Frozen" stoppers can be removed by splitting them with a razor blade and then reclosing them with rubber glue.

Chemical Disposal

The safe disposal of extremely dangerous, unwanted, unlabeled, or contaminated chemicals is a major concern in science teaching.[1] No longer is the "solution to pollution," dilution. National efforts, through new laws, public awareness campaigns, and research findings, make us cognizant of the importance of protecting our environment from chemical pollution.

Disposal procedures are numerous and some are complex. However, the recommended procedures listed in the Laboratory Waste Disposal Manual, published by the Manufacturing Chemists Association, 1825 Connecticut Avenue, N. W., Washington, DC 20009, should cover most chemicals found in the science laboratory. The publication contains 29 disposal procedures, each describing proper handling equipment, procedures for safe disposal of spills or package lots, and examples of each procedure. In addition, an alphabetical reference chart provides an index to the recommended disposal procedures as well as numerous physical properties of over 1,100 elements

[1]A free, 1,000-page catalog, Handbook of Organic and Biochemicals, containing basic data and waste disposal procedures may be obtained by writing to the Aldrich Chemical Company, 940 W. Saint Paul Avenue, Milwaukee, WI 53233.

and compounds. The above publication, priced $2.50 in 1977, is highly recommended for school systems with disposal problems.

Landfill

The following is a partial listing of elements and compounds that, according to the Manufacturing Chemists Association's publication, can be dumped into landfills or released into the air:

- Argon
- Asphalt
- Batteries, dry cell
- Boron
- Bromochloromethane
- Bromotrifluoromethane
- Calcium carbonate
- Calcium oxide
- Carbon black
- Carbon tetrafluoride
- Chlorobromomethane
- Chromium
- Crude lime
- Dichloromethane
- Dichloromonofluoromethane
- Epoxy resin systems
- Ferrosilicon
- Helium
- Hexachloroethane
- Hexafluoroethane
- Hydrogen
- Lamp bulbs
- Latex
- Magnesium oxide
- Metal scrap
- Molybdenum, insoluble compounds
- Neon
- Nitrogen
- Nitrogen fertilizers
- Nitrogen trioxide
- Oxygen
- Ozone
- Paint
- Pyrethrum
- Resins
- Rubber
- Scrap glass
- Scrap stoneware
- Silica
- Sludges
- Stone, alberine
- Sulfur
- Sulfur hexafluoride
- Tar
- Tin, organic compounds
- Titanium oxide
- Tremolite
- Trifluoromethane
- Urea
- Zinc oxide

Drain

Small amounts of dilute acids, bases, or salt solutions may be flushed down the drain with large amounts of water. All material should be soluble in water. Volatile, corrosive, toxic, or insoluble materials should never be flushed down the drain. Chemical waste should not be permitted to accumulate. Items should be properly disposed of immediately after they are no longer needed or wanted.

Acquisition and Reprocessing

Some chemical companies will accept an process certain chemicals on a limited basis. If assistance is needed in ascertaining the names of such companies, contact the Division of Science Education, State Department of Public Instruction, Raleigh, NC 27611, (919) 733-3694.

Science and Laboratory Activities

Laboratory and other science-related activities should be the heart of the science curriculum. Accidents can be prevented or minimized when engaging in science work if students and teachers are cognizant of the potential dangers associated with the activity. There are potential safety hazards associated with all science courses.

Life Science

Field Trips

Field trips and outside activities are an essential part of the science curriculum. One of the most effective ways to study some of the natural phenomena is to observe them in their own peculiar setting. A field trip can be a valuable teaching/learning experience for the science teacher and the students. In order to make it so, careful planning is required. A poorly planned field trip can be a waste of time and even worse than no trip at all. In addition to having well-stated educational objectives, including pretrip preparation and effective follow-up activities and discussion, every precaution should be taken to assure the safety of students and teaching personnel while taking a field trip. The following list of general safety guidelines, if followed, can make field trips safer and more effective as teaching strategies:

- Visit the site prior to the actual field trip. The teachers should have a thorough knowledge of the field trip area, including obvious dangers such as poisonous plants, snakes, water dangers, fall areas, and electrical hazards.
- Establish rules for safe conduct prior to taking the trip.
- Students should be fully instructed about the potential dangers of an area, especially when field trips are to be conducted near deep water or rapid currents.
- Dress properly for the terrain and weather. (Don't forget proper shoes.)
- Have adequate supervision (teachers and/or parents) for the class size.

- Use a "buddy" system. Paired students, each responsible for the other, can help in keeping track of the class.
- A basic first-aid kit is essential and should be standard equipment for a field trip. A snake bite kit should be carried if the field trip includes a poisonous snake's habitat.
- Proper consent, according to school policies, should be obtained prior to any field trip. This may include parental and/or administrative consent.
- Glass collection jars or containers should be avoided. The use of plastic, paper, or cloth containers may prevent cuts and loss of specimens due to breakage.
- A post-field trip check for mite and tick infestations, scratches, cuts, etc., should be conducted when appropriate.
- "Be Prepared."

Poisonous Plants

Poison ivy, poison oak, and sumac immediately come to the minds of most people when poisonous plants are mentioned. However, in addition to these, there are many other plants which are dangerous. According to the U.S. Public Health Service, about 12,000 children are poisoned by plants each year. Many become violently sick and some die. In many cases, teachers and parents are not even aware of the danger of many plants.

There are over 700 plant species known to cause death or illness. When poisonous plants are used in the school, encountered on field trips or at home, students need to be made aware of the potential dangers. The following is a list of common poisonous plants taken from the Family Safety Magazine of the National Safety Council.

[*House Plants*]

Plant	Toxic Part(s)	Symptoms
Hyacinth, Narcissus, Daffodil	Bulbs	Nausea, vomiting, diarrhea. May be fatal.
Oleander	Leaves, branches	Extremely poisonous. Affects the heart, produces severe digestive upset, and has caused death.
Dieffenbachia (Dumb Cane) Elephant's-ear	All parts	Intense burning and irritation of the mouth and tongue. Death can occur if base of the tongue swells enough to block the air passage of the throat.
Rosary pea, Castor bean	Seeds	Fatal. A single rosary pea seed has caused death. One or two castor bean seeds are near the lethal dose for adults.
Poinsettia	Leaf	One leaf can kill a child.
Mistletoe	Berries	Can be fatal.

[*Flower Garden Plants*]

Larkspur	Young plant, seeds	Digestive upset, nervous excitement, depression. May be fatal.
Monkshood	Fleshy roots	Digestive upset and nervous excitement.
Autumn crocus, Star-of-Bethlehem	Bulbs	Vomiting and nervous excitement.
Lily of the valley	Leaves, flowers	Irregular pulse, usually accompanied by digestive upset and mental confusion.
Iris	Underground stems	Severe, but not usually serious, digestive upset.
Foxglove	Leaves	One of the sources of the drug digitalis, used to stimulate the heart. In large amounts, the active principles cause dangerously irregular pulse, usually digestive upset and mental confusion. May be fatal.
Bleeding heart (Dutchman's-breeches)	Foliage, roots	May be poisonous in large amounts. Has proved fatal to cattle.

[*Vegetable Garden Plants*]

Plant	Toxic Part(s)	Symptoms
Rhubarb	Leaf blade	Fatal. Large amounts of raw or cooked leaves can cause convulsions, coma, followed rapidly by death.

[*Ornamental Plants*]

Plant	Toxic Part(s)	Symptoms
Daphne	Berries	Fatal. A few berries can kill a child.
Wisteria	Seeds, pods	Mild to severe digestive upset. Many children are poisoned by this plant.
Golden chain	Bean-like capsules in which the seeds are suspended	Severe poisoning. Excitement, staggering, convulsions, and coma. May be fatal.
Laurel, Rhododendron, Azalea	All parts	Fatal. Produces nausea and vomiting, depression, difficult breathing, prostration, and coma.
Jessamine	Berries	Fatal. Digestive disturbance and nervous symntoms.
Lantana camara (red sage)	Green berries	Fatal. Affects lungs, kidneys, heart, and nervous system. Grows in the southern U.S. and in moderate climates.
Yew	Berries, foliage	Fatal. Foliage more toxic than berries. Death is usually sudden without warning symptoms.

[*Trees and Shrubs*]

Plant	Toxic Part(s)	Symptoms
Wild and cultivated cherries	Twigs, foliage	Fatal. Contains a compound that releases cyanide when eaten. Gasping, excitement, and prostration are common symptoms that often appear within minutes.
Oaks	Foliage, acorns	Affects kidneys gradually. Symptoms appear only after several days or weeks. Takes a large amount for poisoning. Children should not be allowed to chew on acorns.
Elderberry	Shoots, leaves, bark	Children have been poisoned by using pieces of the pithy stems for blowguns. Nausea and digestive upset.

[*Trees and Shrubs* (Cont.)]

Plant	Toxic Part(s)	Symptoms
Black locust	Bark, sprouts, foliage	Children have suffered nausea, weakness, and depression after chewing the bark and seeds.
	[*Wooded Area Plants*]	
Jack-in-the-pulpit	All parts, especially roots	Like dumb cane, contains small needle-like crystals of calcium oxalate that cause intense irritation and burning of the mouth and tongue.
Moonseed	Berries	Blue, purple color, resembling wild grapes. Contains a single seed. (True wild grapes contain several small seeds.) May be fatal.
Mayapple	Apple, foliage, roots	Contains at least 16 active toxic principles, primarily in the roots. Children often eat the apple with no ill effects, but several apples may cause diarrhea.
	[*Swamp or Moist Area Plants*]	
Water hemlock	All parts	Fatal. Violent and painful convulsions. A number of people have died from hemlock.
	[*Field Plants*]	
Buttercup	All parts	Irritant juices may severely injure the digestive syste..
Nightshade	All parts, especially the unripe berry	Fatal. Intense digestive disturbances and nervous symptoms.
Poison hemlock	All parts	Fatal. Resembles a large wild carrot. Used in ancient Greece to kill condemned prisoners.
Jimson weed (thorn apple)	All parts	Abnormal thirst, distorted sight, delirium, incoherence, and coma. Common cause of poisoning. Has proved fatal.

[*General Plant Use Rules*]

1. Become familiar with dangerous plants in your environment.

2. Do not put any part of a plant in the mouth unless absolutely sure of its safety.

3. Do not rub plant sap or juice into skin or open wound.

4. Do not inhale or expose skin or eyes to the smoke of any burning plant.

5. Do not pick unknown cultivated or wildflowers.

6. Do not eat food or drink fluids after handling plants prior to a thorough washing and rinsing of hands.

7. Remember, there are no "safe tests" or "rules of thumb" for distinguishing nonpoisonous from poisonous plants.

8. Breathing spores or pollen can cause reactions in many individuals which may later lead to allergies or diseases.

[*Resources*]

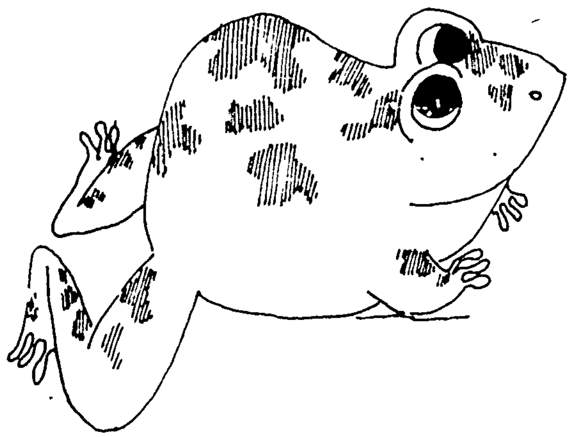
Human Poisoning from Native and Cultivated Plants by James W. Hardin and Jay M. Arena is an excellent reference on poisonous plants. The 194-page book contains photographs, black/white and color, and illustrations. Scientific and common names are given along with description, occurrence, poisoning, and guide to the physician. The publisher is Duke University Press, Durham, NC 27708, 1977 price $6.75.

"Plants That Poison." Up to ten free copies of this chart can be obtained by writing to Ciba-Geigy Corporation, Direct Mail Department, P. O. Box 11422, Greensboro, NC 27409.

Animals in the Classroom

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

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



Current rules and regulations for the Westinghouse Science Scholarships and Awards, which govern the Annual Science Talent Search, state: "No project involving live vertebrate animal experimentation will be eligible. Projects involving human beings, and those on behavioral observations of animals in their natural habitat, are excluded from this ruling and are eligible."

At the 27th International Science and Engineering Fair in May 1976, Dr. M. W. Fox of the Humane Society of the U.S. reported that the overall trend of animal experiments was technique-oriented, repetitious, inhumane, and unimaginative. Several examples cited by Dr. Fox as inhumane are:

- A 16-year old student attempted to graph skin on mice. Some mice broke the stitches. The student used suture material of improper size. Some mice died, possibly as a result of being too cold. The student responded that he/she was not furthering science because the results were already known, but his/her project had been fun.

- A 15-year old student used a cat with apparently badly infected dog wounds to determine whether or not the cat's licking of the wounds would enhance healing. Information on the source of the cat was not available.

- A 17-year old student used cardiac punctures to remove blood from rats in a study of the effects of tumors on blood serum proteins. "Many highly trained professional scientists can't perform cardiac punctures properly," said Dr. Barbara Orlan.

[Federal Animal Welfare Legislation][1]

1966--Federal Laboratory Animal Welfare Act--A mandate was established to ensure the humane treatment of animals in scientific research and experimentation.

1970--Congress passed the Animal Welfare Act Amendments to include non-laboratory animals transported, bought, or sold for teaching purposes or for use as pets.

1976--A new Animal Welfare Act Amendment ensures an effective means of ending inhumane abuses involving animal transportation.

[Classroom Animal Use Guidelines]

- A science teacher or other qualified adult supervisor should assume primary responsibility for the conditions under which any study that involves live animals is conducted. If the school faculty does not include persons with training in the proper care of laboratory animals, the services of such a person on a consulting basis should be sought. Often a local veterinarian is pleased to offer this kind of help.

- Each study involving animals should have as a clearly defined objective the teaching/learning of some scientific principle(s).

- All animals used must be lawfully acquired in accordance with state and local laws.

- Studies involving anesthetic drugs, surgical procedures, pathogenic organisms, toxicological products, carcinogens, or radiation, should be undertaken only under the direction of a certified teacher or

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[1] The Humane Society News, Humane Society of the United States, 2100 L Street, N. W., Washington, DC 20037, Summer/Fall 1976, p. 1.

other qualified adult (e.g., biologist, dentist, physician, or veterinarian) trained in the experimental procedure involved.

- All mammals used in a classroom should be inoculated for rabies, unless purchased from a reliable scientific company.

- The following animals should never be brought into the classroom: wild rabbits, snapping turtles, poisonous snakes, or insects that may be disease carriers. Students should not bring their pets to the classroom unless the activity is carefully planned by the teacher.[1]

- Before a small animal is brought into the classroom for observation, plans should be made for proper habitat and food. The living quarters of animals in the classroom must be kept clean, free from contamination, and secure enough to confine the animals. Plans should be made for care of classroom animals over the weekends and during vacation periods.

- Animals should be handled only if it is necessary. This handling should be done properly according to the particular animal. Special handling is required if the animal is excited, is feeding, is pregnant, or is with its young.

- Students should wash their hands after handling turtles, snakes, fish, frogs, toads, etc. Also, the water from the habitat should be disposed of carefully.

- Students should be cautioned never to tease the animals or to insert their fingers or objects through wire mesh cages.

- Any student who is bitten or scratched by an animal should report immediately to the school nurse.

- After a period of animal observation is completed, animals should be returned to their natural environment.

[*U.S. Humane Society Guidelines*][2]

- In biological procedures involving living organisms, species such as plants, bacteria, fungi, protozoa, worms, snails, or insects should be used wherever possible. Their wide variety and ready availability in large number, the simplicity of their maintenance and subsequent disposal, makes them especially suitable for student work. In mammalian studies, nonhazardous human experiments are often educationally preferable to those using species such as gerbils, guinea pigs, or mice.

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[1] As of June 1975, the U.S. Food and Drug Administration has banned the sale of pet turtles in the U.S. because turtles are proven transmitters of infectious salmonella to children.

[2] "HSUS Guiding Principles for Use of Animals in Elementary and Secondary Education." (Available free of charge from the Humane Society of the United States, 2100 L Street, N. W., Washington, DC 20037.)

- No procedure shall be performed on any warmblooded animal that might cause it pain, suffering, or discomfort or otherwise interfere with its normal health. Warmblooded animals include man, other mammals such as gerbils, guinea pigs, mice, rabbits, hamsters, and rats. It also includes birds such as hens, quail, and pigeons. This means that a student shall do unto other warmblooded animals only what he can do to himself without pain or hazard to health.

- No surgery shall be performed on any living vertebrate animal (mammal, bird, reptile, or amphibian).

- No lesson or experiment shall be performed on a vertebrate animal that employs microorganisms which can cause disease in man or animal, ionizing radiation, cancer-producing agents, chemicals at toxic levels, drugs that produce pain or deformity, extremes of temperatures, electric or other shock, excessive noise, noxious fumes, exercise to exhaustion, overcrowding, or other distressing stimuli.

- Animal observations must be directly supervised by a competent science teacher who shall approve the plan before the student starts work. Students must have the necessary comprehension and qualifications for the work contemplated. The supervisor shall oversee all experimental procedures, shall be responsible for their nonhazardous nature, and shall personally inspect experimental animals during the course of the study, to ensure that their health and comfort are fully sustained.

- Vertebrate studies shall be conducted only in locations where proper supervision is available; either in a school or in an institution of research or higher education. No vertebrate animal studies shall be conducted at a home (other than observations of normal behavior of pet animals such as dogs or cats).

- In vertebrate studies, palatable food shall be provided in sufficient quantity to maintain normal growth. Diets deficient in essential foods are prohibited. Food shall not be withdrawn for periods longer than 12 hours. Clean drinking water shall be available at all times (and shall not be replaced by alcohol or drugs).

- Birds' eggs subjected to experimental manipulations shall not be allowed to hatch; such embryos shall be killed humanely no later than the nineteenth day of incubation. If normal egg embryos are to be hatched, satisfactory arrangements must be made for the humane disposal of chicks.

- In the rare instances when killing of a vertebrate animal is deemed necessary, it shall be performed in an approved humane (rapid and painless) manner by an adult experienced in these techniques.

- Projects involving vertebrate animals will normally be restricted to measuring and studying normal physiological functions such as normal growth, activity cycles, metabolism, blood circulation, learning processes, normal behavior, reproduction, communication or isolated organ techniques. None of these studies requires infliction of pain.

- The comfort of the animal observed shall receive first consideration. The animal shall be housed in appropriate spacious, comfortable, sanitary quarters. Adequate provision shall be made for its care at all times, including weekend and vacation periods. The animal shall be handled gently and humanely at all times.

- Respect for life shall be accorded to all animals, creatures, and organisms that are kept for educational purposes.

[*Resources*]

Guiding Principles in the Use of Animals by Secondary School Students and Science Club Members, and A Study Guide: Animals in Biology, may be obtained free of charge by writing to the National Society for Medical Research, 1330 Massachusetts Avenue, N. W., Washington, DC 20005.

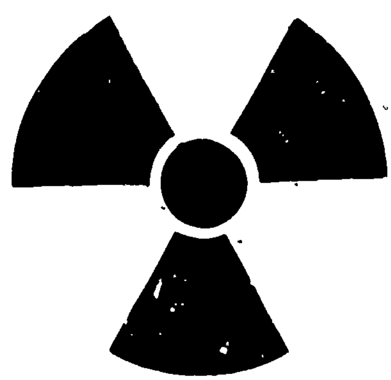
"How to Care for Living Things in the Classroom," Grace K. Pratt, National Science Teachers Association, 1742 Connecticut Avenue, N. W., Washington, DC 20009, 1965, 16 pp., ERIC #ED 064 135.

Humane Biology Projects and First Aid and Care of Small Animals can be obtained free of charge from the Animal Welfare Institute, P. O. Box 3650, Washington, DC 20007.

"Small Animals in the Classroom," Dietrich C. Smith, The American Biology Teacher, Vol. 22, No. 8, November 1960, pp. 471-477.

Radiation Sources

Today's atomic age provides ample opportunities for students to learn about radiation through classroom demonstrations and student experimentation. Because of the increased use and availability of radioactive materials, high energy-producing devices, as well as new knowledge on the hazards of radiation, every precaution should be taken to prevent human absorption of ionizing and nonionizing radiation.



Ionizing Radiation

[*Radioisotopes*]

The U.S. Energy Research and Development Administration (formally the AEC) has approved certain weak radioisotopes for classroom use. These isotopes do not require a special license. Even though the level of radioactivity is in the low microcurie range and does not require complex safety measures, the following procedures are recommended:

1. All radioisotopes should be labeled, "RADIOACTIVE," including indications of level of radioactivity, date of assay, kind, and quantity.

2. Storage should be in a locked cabinet that is clearly marked, "RADIOACTIVE MATERIAL."

3. Eating, drinking, or use of cosmetics should not be permitted in the general area where radioactive materials are.

4. Avoid getting radioisotopes near the eyes, mouth, or open sores.

5. Do not pipette radioactive solutions by mouth.

6. Avoid inhalation of fumes from reactions involving radioactive materials. Such reactions should be performed in a fume hood.

7. Avoid contamination of hands by using appropriate handling apparatus such as tongs and rubber gloves. Wash hands after each experiment and test with a Geiger counter.

8. Check all radioactive specimens brought into the laboratory to be certain the radiation is not at a dangerous level.

9. Good housekeeping should be maintained at all times. Do not allow waste or contaminated material to accumulate.

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

1. Solutions may be diluted with large amounts of water and flushed down the drain.

2. Solid materials and trash may be incinerated.

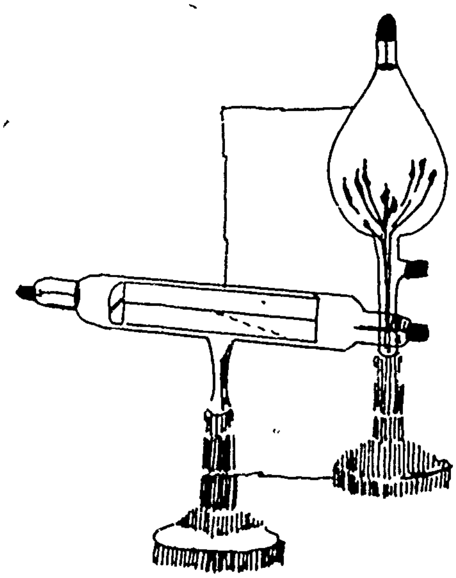
Consult with the Energy Research and Development Administration (ERDA), Office of Public Affairs, Washington, DC 20545, for disposal or use of radioisotopes of radiation levels above the microcurie range.

[X-ray Machines]

According to a recent North Carolina law, all X-ray machines must be registered with the State of North Carolina. No X-ray machine should be possessed or used by any school unless it has been registered with the Radiation Protection Branch, N. C. Department of Human Resources, P. O. Box 12200, Raleigh, NC 27605, (919) 733-4283. The Radiation Protection Branch should be contacted regarding matters concerning radiation-producing equipment or radioactive sources. Consultative services are available free of charge.

Registered X-ray machines should never be used on students for demonstration or any other purposes. All teachers using X-ray equipment should be thoroughly familiar with the potential hazards and proper safety precautions.

In addition to X-ray tubes, any device which uses electron beams, such as cathode ray tubes, television tubes, rectifier tubes, or microwave tubes, are all capable of producing X-rays.



[Cold Cathode Ray Tube Hazards]

The U.S. Public Health Service study has shown that three types of cathode ray tubes commonly used for classroom demonstration can produce potentially hazardous X-rays. They are as follows:

1. The heat effect tube. This tube is used to demonstrate that cathode rays consist of rapidly moving electrons where kinetic energy can be converted to heat.

2. The magnetic or deflection effect tube. This tube is used to demonstrate that cathode rays carry an electrical charge and can be deflected by a magnetic field.

3. The shadow or fluorescence effect tube. This tube is used to demonstrate that cathode rays may be converted into visible radiation by fluorescence of the glass wall of the tube as a result of the electron bombardment.

These tubes can produce X-rays when all of the following four conditions are present:

1. An electron source or cathode.

2. A target or anode which the electrons can strike.

3. A high potential difference exists between the anode and cathode. (In voltage of 10 kV or under, the electrons do not acquire sufficient energy to produce significant X-rays.)

4. Low gas pressure prevails between the cathode and anode, i.e., a moderately good vacuum exists in the tube.

With regard to X-ray production from the tubes under discussion, the following may be concluded:

1. X-ray output is sporadic. Under identical conditions of operation, X-ray production may vary from one tube to another or from the same tube from day-to-day.

2. Gas pressure within the tube is one of the controlling factors in X-ray production. If there is sufficient gas present, the accelerating electrons will collide with gas atoms and thus never gain enough energy to produce X-rays.

3. Tube composition plays an important part in producing X-rays. X-ray production is a function of the target material the electrons strike.

4. The tube wall, if thick enough and of proper composition, can act as a shield for X-rays.

5. The output of the tube is strongly dependent upon the voltage and current capabilities of the power source.

The following procedures are recommended when using tubes like those described above:

1. Tubes should be used only for demonstrations conducted by the instructor. No student should hold the tube.

2. Tubes should always be operated at the lowest possible current and voltage and the time of operation should be kept to a minimum.

3. No student should stand closer than eight feet from a tube when it is operating.

Nonionizing Radiation

[Ultraviolet Rays]

Direct ultraviolet rays, unless proper shielding is provided, can be absorbed in the outer layers of the eye--the cornea and conjunctiva. Such absorption will create an inflammation of the conjunctiva called "conjunctivitis." This damage will ordinarily become apparent from four to eight hours after exposure and will have a duration of approximately three days. Students should be advised to wear proper protective glasses if the source is not already shielded. They should be further informed that mercury light sources are capable of emitting ultraviolet rays and, therefore, protection should be provided when using such equipment.

[Infrared Rays]

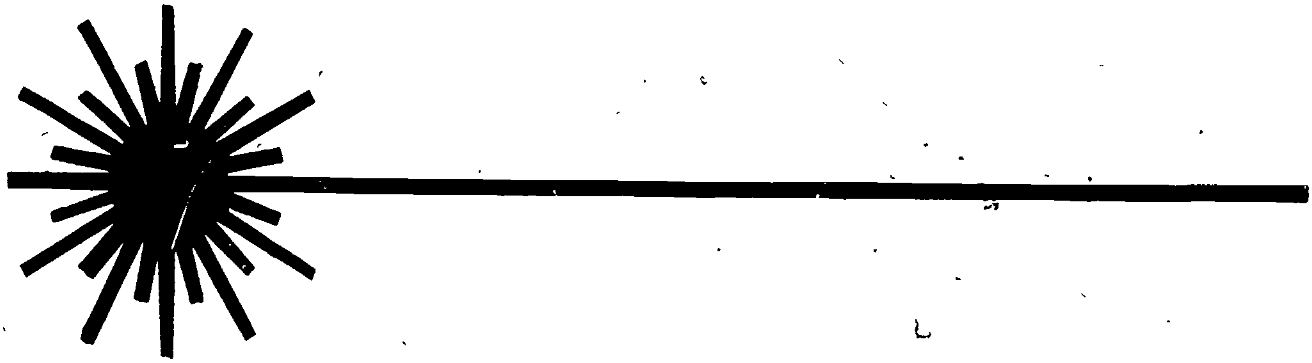
Excessive exposure to infrared rays can damage the eye lens and produce cataracts. As in the case of ultraviolet rays, students using infrared equipment should be provided with the necessary shielding and the duration of the exposure should be limited.

[Microwave Transmitter Hazards]

Human absorption of microwaves, especially of high intensity, is strongly suspected as a health hazard. Teachers and students should avoid unnecessary exposure, especially about the head at close range.

[Resource]

Radiation Protection in Educational Institutions is a recommended publication for teachers using radiation sources in the science curriculum. It is available for $2.00 (1977 price) from the National Council on Radiation Protection, P. O. Box 30175, Washington, DC 20014.



Laser Safety

Laser use in the classroom is a potential hazard. Changes in retinal cell structure can result from long-term exposures to low output lasers. Hazards may not be immediately manifested.

The following facts were uncovered through a survey conducted by the Food and Drug Administration, Bureau of Radiological Health:

- Helium-neon lasers account for 92 percent of lasers used in high schools and 79 percent of lasers used in colleges.

- Lasers specified or rated at 1.0 milliwatt radiated in the range of 0.19 to 3.0 milliwatts. Similar variations were measured for other specified powers. In general, the optical power specification is not a reliable index of the output for lasers purchased prior to August 1976.

- Only half of the laser users surveyed had, or could locate, instruction manuals which contained any safety advice or information.

- No laser surveyed had any statement of output power on it.

- A value of 7 milliwatts has been stated to be the power of a He-Ne laser required to produce a retinal burn in experimental animals.[1] The 7-milliwatt figure represents a calculated power that produces retinal burns in 50 percent of exposed monkeys. The actual experiments utilized five monkeys. The data showed that a raw unfocused beam entering the eye at 1.9 milliwatts for 1 second produced a retinal burn in one monkey.

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[1] W. T. Ham, "Retinal Burn Thresholds for the Helium-Neon Laser in the Rhesus Monkey," Archives of Ophthalmology 84 (6): 797-809, 1970.

- Production of visible retinal burns in Rhesus monkeys exposed to 2.0 milliwatts for 1 second has been independently reported.[1]

- Human injury from a Helium-Neon laser has been reported.[2] A visible retinal burn was produced from an accidental exposure to a power of 2 milliwatts for an estimated one to two seconds.

- Changes in retinal cells can be observed with the microscope after exposures to laser beams at powers less than those required for retinal burns.[3] Deleterious effects at the microscopic level may occur at optical radiant powers perhaps as much as 100 times lower than powers expected to produce visible retinal burns.

The Federal Laser Products Performance Standards[4] became effective in August 1976. All lasers sold after this date should be appropriately labeled as to power output and primary wavelength. Lasers purchased prior to the 1976 standards may have energy outputs greater than specified.

Most lasers used in schools are classified as Type II, having an output of 1 milliwatt or less, and of the continuous spectrum-type. It is very easy to avoid laser hazards by implementing the following safety rules:

- Avoid direct viewing of the beam. Direct propagation of the laser beam from the laser into the eye of an observer should be avoided at all times. As a general practice, do not place any portion of the body in the beam. This practice becomes increasingly important as the output power of the laser device increases. Good work practices, developed early, will later assist the individual in working safely with higher output units.

- Remove unnecessary objects from the path of the beam. Objects with mirror-like finishes reflect laser beams. Viewing the reflected beams should also be avoided. Demonstration equipment, such as support rods and bench surfaces, should be painted or treated to produce a dull, nonreflective surface. All optical components should be rigidly fixed with respect to their position relative to the laser.

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[1] Frisch, "Retinal Injury Thresholds from Argon Laser Radiations," Department of Army, Frankford Arsenal, Memorandum Report m70-21-1, June 1970.

[2] C. E. Armstrong, "Eye Injuries in Some Modern Radiation Environments," Journal of the American Optometric Association 41 (1) 55-62, 1970.

[3] "Preliminary Documentation Report-Biological Aspects and Other Bases for the Performance Standard for Laser Products," BRH-DBE, October 1972.

[4] Laser Products Performance Standards, Federal Register Vol. 40, No. 148, July 31, 1975, U.S. Department of Health, Education, and Welfare, Rockville, MD 20852.

- Block the beam when it is not needed. Add a shutter or cap which can be operated to allow the beam to radiate ONLY when necessary for measurements or observations.

- Terminate laser beams. All laser beams should be terminated in a non-reflective, light-absorbing material.

- Prepare and test demonstrations without others present. Demonstrations should be prepared and tested by the instructor without others present. The possibility of an unexpected reflection should always be considered.

- Deflect beam in a vertical plane. Complex experiments or demonstrations involving reflection or refraction should be conducted with the beam deflection angles contained in a vertical plane. The laser display system should be contained in a box, open on the side(s), but closed on the ends, top and bottom. The laser beam axis should be established at a level below or above the eye level height of the instructor or observers.

- Affix expanding lenses rigidly to the laser. When the laser is used to illuminate large surfaces, as in the viewing of holograms, beam expanding lenses should be rigidly fixed to the laser.

- Equip laser with a key switch. The laser should be equipped with a key switch in the primary power circuit, rather than with the more commonly used toggle-type switch. Key switches are available from electronic supply stores for a relatively small charge.

- Do not leave an operable laser accessible and unattended.

- Reduce optical power. The optical power used should be reduced to the minimum necessary to accomplish the objective. Neutral density filters or colored plastic can be used effectively to reduce radiated optical power.

- Keep the area well-lighted at all times. This tends to keep the pupil of the eye relatively contracted and reduces the light impinging on the retina accidently when the laser system is in use.

- Provide and use adequate protective devices. Eye protection with shatter-resistant goggles is essential for some type of laser systems, but no one type of goggle offers protection for all wavelengths. Make sure that proper goggles are available and used.

- Protect against electrical shock. The possibility of electrical shocks from both high and low voltage equipment, including storage capacitors and power supplies, can be avoided by proper design.

- Shield the pump source. High-intensity light generated by the pump source should not be viewed directly. Shielding is essential.

Further information on laser safety is available. Single copies of a safety pamphlet, Safety in Classroom Laser Use, and a book, Laser Fundamentals and Experiments, may be obtained free from Office of Information (RH-50), Bureau of Radiological Health, Food and Drug Administration, 5600 Fishers Lane, Rockville, MD 20857.

Lasers with outputs of greater than 1 milliwatt present potential hazards different from those listed above. Schools using lasers in this range or larger might benefit from the following reference: "Safe Use of Lasers," Z-136.1, 1976, American National Safety Institute, 1430 Broadway, New York, NY 10018, 1977 price $9.00.

Hazards in Viewing the Sun

Direct viewing of the sun for any reason is extremely hazardous. Indirect methods of viewing sunspots, solar eclipses, etc., are the only safe methods known. The following information on the 1970 eclipse was prepared and sent to schools in North Carolina:

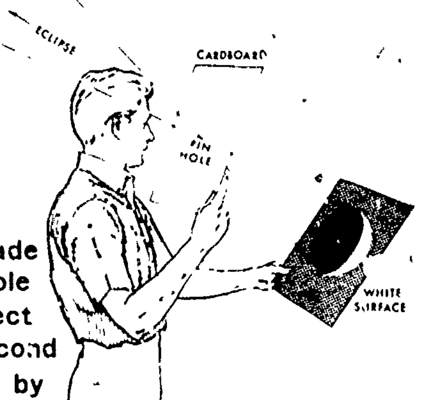
DANGER

SOLAR ECLIPSE MARCH 7, 1970

Sunglasses, smoked glass, exposed photographic film, and welder's goggles ARE NOT SAFE for watching the eclipse. Only by indirect methods, such as television or simple projection devices, can this phenomenon be observed without risking damage to the eyes, warns the National Society for the Prevention of Blindness, Inc.

USE ONLY INDIRECT METHODS:

1. Watch television. Without question, the safest method for viewing a solar eclipse is by watching it on television.



2. Use the indirect pinhole method. A simple projector for observing the eclipse can be made with two pieces of white cardboard. A pinhole or pencil hole in the top piece serves to project and focus the image of the eclipse on the second piece. The size of the image can be changed by altering the distance between the two pieces of cardboard. DO NOT LOOK AT THE SUN THROUGH THE PINHOLE.

EYE DAMAGE DURING ECLIPSES

In 1959, 170 people, mostly school children suffered permanent damage to the sight of one or both eyes.

In 1963, one-half of the country's ophthalmologists reported 247 cases of visual damage.

ACCORDING TO MEDICAL AUTHORITIES

The danger of the retinal burn comes from the invisible infrared rays which penetrate light filters and instantaneously damage eyes. The retina is not sensitive to pain, henceforth the victim might not immediately be aware of eye damage. Retinal burns are incurable and destroy the field of fine vision. The victim's ability to read is lost forever.

The March 7 eclipse will be total in the eastern part of North Carolina. The next total eclipse in the continental United States will occur in 1979 in the northwest corner of the United States. The path of totality will be about 80 miles wide and will follow a line from Elizabethtown to to Greenville before striking eastern Virginia and moving out into the Atlantic Ocean. Raleigh and Wilmington will be just out of the path of totality. All parts of North America, except Alaska, will experience the partial eclipse.

... Raleigh, North Carolina 27602

Dangerous Substances and Reactions

New potential dangers are constantly being recognized in substances and reactions that were once considered safe. The following is a partial listing of such substances and reactions.

General

- Common organic solvents like benzene, methyl alcohol, acetone and many others can have a serious toxic effect if inhaled over an extended period. Their use requires good window ventilation or a fume hood.

- PTC papers are normally used in biology programs. A cautious attitude is advised toward the use of PTC (phenylthiocarbamide or phenylthiourea) taste papers. The PTC test papers are used to illustrate the genetic transmission of the ability to taste the compound within a family. The FDA has not approved PTC. The substance is described as a rodenticide in Dangerous Properties of Industrial Chemicals. According to the Merck Index, the lethal dose for rats is 40 mg/kg of body mass.

- Chronic pencil chewers may be getting lead poisoning from the paints used on some pencils.

- Carbon tetrachloride is extremely poisonous and is rapidly absorbed by the body both in liquid and vapor form. It was banned from sale for home use by the FDA in 1971. Most poisonings are due to inhaling fumes. The recommended safe tolerance for air is 10 ppm (parts per million). However, it is not detected by smell until the concentration in the air reaches 80 ppm. It can cause acute liver damage and kidney failure. Some individuals are more susceptible than others depending upon age, obesity, and general health. No specific treatment or antidote is known. Almost all body cells are affected by the toxin. Most school laboratories' chemical supplies contain carbon tetrachloride. It should be used only when absolutely necessary and with extreme caution in a well-ventilated area. It should never be used as a fire extinguishing medium or as an agent in insect-killing containers.

- Potassium chlorate is one of the most frequent causes of serious explosions because of its strong oxidizing power and sensitivity to shock. Slight amounts of combustible impurities like carbon or sulfur may cause an explosion through mild friction or impact. Potassium chlorate should be tested in advance for impurities with small amounts before being used in demonstrations or class experiments. Some chemists have suggested eliminating it from school laboratory shelves completely.

- Chemicals that are active on water like hydrogen peroxide, calcium carbide, and calcium oxide should be kept in airtight and waterproof containers when not in use, to avoid fire or explosion. Calcium carbide, in addition, produces highly combustible acetylene when reacting with water. If sodium or potassium is used, students should be cautioned about handling it. The teacher should dispense these metals in small pieces. Students should not have access to large chunks of these metals. The temptation to use too much is hard to overcome. Students should also be warned about the spattering of sodium.

- Ammonium dichromate to simulate volcanic eruptions in volcano models is hazardous. The compound is toxic, flammable, and may react explosively with certain organic compounds. It should be kept in a tightly closed container and away from an open flame. The vapors may have a corrosive action on the skin and mucous membranes, causing a rash or external ulcers. Ammonium dichromate can emit highly toxic fumes when heated. A substitute is strongly recommended in place of this compound for such a demonstration.

- Chlorine gas is very poisonous and hence should be made only in small quantities. Only the most reliable students should be permitted to perform the experiment of making the gas, and then, only after having been specifically advised as to the hazards involved. One generator may be set up on each table or in hood compartments. Adequate ventilation must be provided to prevent the accumulation of dangerous quantities of the gas in the room. The experiment should be supervised closely by the instructor at all times.

Carcinogens

In January 1975, the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), declared 14 chemicals to be cancer-causing substances (carcinogens). A survey by the N. C. Department of Labor (OSHA), in April 1976, found all of the 14 carcinogens in N. C. public schools.

These compounds should be safely stored or disposed of if they are among the school science laboratory supplies. The only exception to the ban on their use in the science program should be if they are absolutely essential for special projects under strict personal supervision by a certified science teacher who is knowledgeable in the handling and use of such compounds. These compounds are extremely toxic; even at levels of one part per billion (1 ppb). The toxic effects of these compounds in humans may not show up for 20 years or more.

Note: If information is needed on proper storage/disposal methods, contact the N. C. Department of Labor, Occupational Safety and Health Division, P. O. Box 27407, Raleigh, NC 27611.

Listed below are the 14 carcinogens discussed above:

- 4-Nitrobiphenyl (4-NBP)

  Other names include: 4-Nitrodiphenyl; p-Nitrobiphenyl; and p-Nitrodiphenyl.

- Alpha-Naphthylamine (1-NA)

  Other names include: 1-NA; Naphthylamine; Fast Garnet Base B; Antioxidant-Mb; 1-Aminonaphthalene; Naphthalidam; and Naphthalidine.

- 4,4'-Methylene bis (2-chloroaniline)

  Other names include: MOCA.

. Methyl chloromethyl ether (CMME)

Other names include: chlorodimethyl ether; chloromethyl ether; and chloromethyl methyl ether.

. 3,3' Dichlorobenzidine (and its salts)

Other names include: 4,4' Diamino; 3,3'-Dichlorobiphenyl; 4,4' Diamine; o,o'-Dichlorobenzidine; and similar names.

. Bis (chloromethyl) ether (BCME)

Other names include: Chloro (chloromethoxy) methane; sym-Dichloromethyl ether; and similar names.

. Beta-Naphthylamine (2-NA)

. Benzidine

Other names include: Fast Corinth Base B; p-Diaminodiphenyl; 2-Aminodiphenyl; C.1. Azoic Diazo Component 112; p-p'-Bianiline; Benzidine dihydrochloride; Benzidine sulfate; and 4-4' Diaminobiphenyl.

. 4-Aminodiphenyl

Other names include: 4-ADP; PAB; Biphenyline; P-Phenylaniline; Xenylamine; P-Aminobiphenyl; and other names.

. Ethyleneimine (EI)

Other names include: Azirane; Azacyclopropane; Aziridine; Dimethyleneimine; Dihydroazirine; and similar names.

. Beta-Propiolactone (BPL)

Other names include: Betaprone (a trademark); 2-oxetanone; propiolactone; B-lactone hydrocrylic acid; 3-Hydroxypropionic acid lactone; and similar chemical names.

. 2-Acetylaminofluorene

Other names include: AAF; 2-AAF; FAA; 2-FAA; 2-Fluorenylacetamide; 2-Acetamidofluorene; and N-Acetylaminophenathrene.

. 4-Dimethylaminoazobenzene (DAB)

Other names include: Solvent Yellow 12; Fat Yellow; Oil Yellow; Cerasine Yellow; DMAB; Brilliant Fast Spirit Yellow; Methyl Yellow; N; Aniline: N-dimethyl-p-(Phenylazo); Benzeneazo Dimethylaniline; and similar names.

. N-Nitrosodimethylamine (DMN)

Other names include: Dimethylamine; Nitrous dimethylamide; N,N-Dimethylnitrosoamine; Dimethylnitramine; and similar names.[1]

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[1] Carcinogens, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, 1977 price $0.50, stock #029-015-00047.

Incompatible Chemicals

Many chemicals react violently, produce toxic fumes, and are fire hazards when they interact. The chemicals listed in the left-hand column should be stored in a manner that will prevent them from coming in contact with those in the right-hand column.

Acetic acid	Chromic acid, nitric acid, perchloric acid, ethylene glycol, hydroxyl compounds, peroxides, and permanganates
Acetone	Concentrated sulfuric and nitric acid mixtures
Acetylene	Bromine, chlorine, fluorine, copper tubing, as well as silver, mercury, and their compounds
Alkali metals (K, Na, Ca), powdered aluminum and magnesium	Water (K & Na), carbon dioxide, carbon tetrachloride, and the halogens
Ammonia, anhydrous	Mercury, hydrogen fluoride, and calcium hypochlorite
Ammonium nitrate (a deliquescent, hygroscopic, powerful oxidizing agent)	Strong acids, metal powders, chlorates, nitrates, sulfur, flammable liquids, and finely divided organic materials
Aniline	Nitric acid and hydrogen peroxide
Bromine	Ammonia, acetylene, butane, hydrogen, sodium carbide, turpentine, and finely divided metals
Carbon, activated	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, strong acids, powdered metals, sulfur, and finely divided organic materials
Chromic acid	Glacial acetic acid, camphor, glycerin, naphthalene, turpentine, lower molecular weight alcohols, and many flammable liquids
Chlorine	Same as for bromine
Copper	Acetylene and hydrogen peroxide
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, sodium peroxide, nitric acid, and the halogens

Hydrocarbons (butane, propane, benzene, gasoline, and turpentine)	Fluorine, chlorine, bromine, chromic acid, and sodium peroxide
Hydrofluoric acid	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, (most metals or their salts), flammable liquids, and other combustible materials
Hydrogen sulfide	Nitric acid and certain oxidizing gases
Iodine	Acetylene and ammonia
Nitric acid	Glacial acetic acid, chromic and hydrocyanic acids, hydrogen sulfide, flammable liquids, and flammable gases which are easily nitrated
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, and gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohols, paper, wood, and other organic materials
Phosphorus pentoxide	Water
Potassium permanganate	Glycerin, ethylene glycol, and sulfuric acid
Silver	Acetylene, ammonia compounds, oxalic acid, and tartaric acid
Sodium peroxide	Glacial acetic acid, acetic anhydride, methanol, carbon disulfide, glycerin, benzaldehyde, and water
Sulfuric acid	Chlorates, perchlorates, permanganates, and water

Note: A copy of the Manual of Hazardous Chemical Reactions is recommended for high school science departments. The 470-page book (491M) is available for $5.00 (1977 price) from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

Mercury

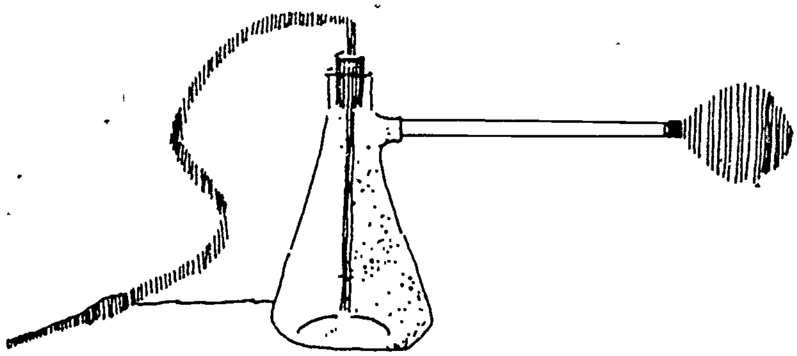
Known since ancient times as quicksilver, for many years mercury was a fun plaything in the science curriculum. With our present environmental concerns and knowledge of recent studies, it is now recognized as a two-headed monster. Mercury and its compounds should be treated with respect and used with utmost care in the school curriculum. Metallic mercury and its compounds can be absorbed into the body by inhalation, ingestion, or through the skin. Poisonous effects are very slow to develop unless large doses in compound or vapor form are absorbed over a short time span.

One of the major concerns of mercury in the schools is its high volatility. When mercury (in element form) is dropped, it breaks into a zillion small droplets. This greatly increases the surface area and thusly the amount of mercury vapor increases proportionally. For example: A teaspoonful of mercury covering an area of about 10 cm^2 will vaporize at normal room temperature in still air at a rate of 0.007 mg/hr. Under such conditions, a room three metres high covering an area of seven square metres will reach dangerous vapor levels in two weeks. Federal and state regulations limit continuous exposure to mercury vapor to 0.1 mg per cubic metre of air.

Dropping mercury on floors, especially wooden floors, with many cracks and crevices, greatly compounds the problem of cleanup. Incidentally, it is virtually impossible to completely cleanup spilled mercury. Even small amounts in the bottom of a drawer can pollute the room atmosphere. Mercury poisoning is cumulative in humans.

[*Using Mercury and Its Compounds*]

- Keep mercury (in element form) containers tightly closed or store underwater. Polyethylene containers are preferred over glass ones from a breakage standpoint.
- Mercury and its compounds should not come in contact with the skin, as it can be absorbed.
- Do not flush mercury or its compounds down the drain. Mercury in solution can be precipitated with a solution of sodium chloride. The precipitant can be discarded with other solid lab waste.
- Use mercury over a tray or pan to prevent spills.
- When mercury is being used over carpet, place a plastic sheet over the area.
- Decomposition of mercuric oxide as a demonstration or experiment should be avoided.
- Use mercury only in well-ventilated areas.



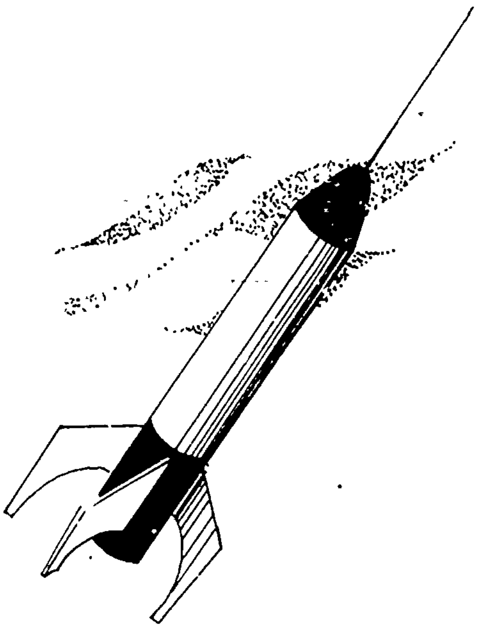
[*Suggestions for Cleaning up Spills*]

- Do not sweep with a broom.
- Do not use a vacuum cleaner unless it is specially designed for such purposes. An aspirator can be made from a wash bottle by attaching a suction bulb to the blowing tube of a wash bottle. Attach a fine pipette or capillary tube to the spout tube. Very small droplets can be vacuumed into the wash bottle. (See above.)
- Push "pools" of mercury together and collect.
- Sprinkle powdered sulfur over the area being sure to cover all mercury. Allow 24 hours for the sulfur and mercury to react. Carefully sweep up the mercury sulfide.
- Spills on <u>smooth surfaces</u> can be cleaned up with a suspension made from 250 ml liquid detergent, 250 ml sulfur, and one litre of water. Mop on surface, let dry overnight. Mop up.
- Wash hands with liquid detergent, not regular soap.
- Take care not to contaminate shoes.

Note: Cleanup assistance or mercury vapor surveys can be obtained by contacting the N. C. Department of Human Resources, Occupational Health, P. O. Box 2091, Raleigh, NC 27601, (919) 733-3680.

Miscellaneous

The safety topics in this section are extremely important. The recommendations should be carefully adhered to where they apply.



Model Rocket Safety

Model rocketry continues to increase in popularity in schools around the country. Aerospace and rocket clubs can, and are, contributing significantly to the science curriculum. However, such school-related activities should be properly supervised and all individuals involved should be made fully aware of potential dangers and of proper safety procedures. Supervising teachers should know that rocket firings may violate Federal Aviation regulations. The following general safety recommendations regarding model rockets are within the FAA regulations:

- Construction--Should be of wood, plastic, paper, rubber, or similar material, and without any metal as structural parts. The total mass of the rocket should not exceed 453 grams, including the engine.

- Engines--Should be solid propellant reaction engines produced by commercial manufacturers. Manufacturers' instructions should be carefully followed and no alteration or reloading of engines should be allowed. Engines should contain not more than 113 grams of propellant. Homemade propellants of any type should not be used.

- Recovery--Model rockets should have a recovery system to prevent substantial damage to the rocket and to prevent hazards for persons and property on the ground. Nonflammable recovery wadding should be used. No attempt should be made to recover rockets from power lines or other dangerous places.

. Stability--A model rocket should be checked for stability prior to the first launching except when launching models of proven stability. Suggested tests are found in an Estes Industries' publication.[1]

. Launching system--Should be remotely controlled and electrically operated by a switch that will return to off when released. A minimum distance of six metres should be maintained between the rocket and all personnel. The system should have a jet deflector to prevent engine exhaust from hitting the ground directly.

. Launching conditions--Rockets should not be launched in high winds, near buildings, power lines, tall trees, or in the paths of flying aircraft or under any condition which might be dangerous to people or property. The launching angle should be more than 60 degrees from the horizon.

. Launching area--Should be a clear area free from easily flammable materials. The smallest dimension of the ground area should be no less than ¼ the anticipated maximum altitude of the rocket to be flown.

. Launch targets and loads--Rockets should not be launched so that the flight will carry it to a ground target. Rockets should not contain explosive or pyrotechnic head.

Note: A detailed, nine-page guide entitled Code for Model Rocketry, 1968 (#41L) is available for $2.00 (1977 price) from the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210. The publication references a federal law under the Federal Aviation Act. Federal Aviation Regulations, Part 101, applies basically to rockets whose total mass is more than 453 grams and whose propellant mass is more than 113 grams. It also applies to rockets that have substantial parts made of metal. For more information, contact any FAA air traffic facility or General Aviation District Office.

Alcohol Lamp

The alcohol lamp is a common and inexpensive heat source. However, teachers and students should be warned of its potential danger. The following are excerpts from the Elementary Science Study Newsletter, No. 21 (June 1970), p. 2:

. "Is the common alcohol lamp used in classrooms around the country a safe laboratory device or a potential bomb?"

. "Alcohol lamps are glass containers with metal covers and wicks. They use a small amount of denatured or wood alcohol as fuel and give a small open flame handy for laboratory experiments."

. "For as long as 50 years they have been regarded as safe and dependable, but Tuesday in Springfield, (Mass.) there was an

[1]Daniel F. Saltrick, Alfred M. Kubota, and Robert L. Cannon, Aerospace Education and Model Rocketry, 2nd edition (Penrose, CO 8. 10: Estes Industries, 1975).

- explosion in a classroom where an alcohol lamp was being used. Three children, a teacher and two aides were injured . . . ."
- In Trumbull, CT, an explosion in an eighth grade science classroom sent six children and a teacher to the hospital . . . ."
- "In each case there was bulk storage of alcohol in a gallon metal can with a pouring spout within five to six feet of a burning alcohol lamp."

Similar accidents have occurred in North Carolina as recently as 1976.

A can of denatured alcohol has explosive potential. The portion above the liquid consists of alcohol vapors which are highly flammable and potentially a powerful explosive hazard. Remember, an alcohol flame is hard to see. If a lit glass alcohol lamp is dropped and breaks, the flame can cover a large area instantaneously.

The following precautions are suggested in regard to the use of alcohol and alcohol lamps:

- The preparation for use and storage of alcohol or other flammable liquids such as ether, gasoline, carbon disulfide, benzene should be in a room away from the laboratory itself.
- Never transport a lit alcohol lamp.
- Use extreme caution with alcohol lamps, especially if they are the glass-type.
- If alcohol is to be heated, it must be in a water bath container with the top of the beaker, etc., holding the alcohol below the top of the water bath container.
- An electrical heat source is preferable over a flame when alcohol or other flammable liquids must be heated.

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