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ABSTRACT

Safety is a very important consideration for science teachers at all levels. Hazardous conditions exist wherever science is taught, whether indoors or outdoors. Many feel that it is important for safety instruction to be an integral part of any science program if teachers are to provide the safest possible environment for their students. Since the courts have become more sensitive to the well-being of the individual, school personnel should accept the safety of each student as one of their major responsibilities. Teachers should know the appropriate steps to take in case of an accident or emergency and be aware of the potential hazards associated with any hands-on activity. This document is designed to serve as a resource for teachers and administrators who are responsible for the safety of students in a science program. It includes topics thought to be essential and pertinent to the various types of science or science related courses offered in elementary and secondary schools. Discussions include legal issues and recommendations, safety in the school science laboratory, the management of chemicals, and safety in school science classes indoors and outdoors. A bibliography of 78 articles, books, catalogs, government publications, and dissertations is included. (CW)

SAFETY FIRST IN SCIENCE TEACHING

DIVISION OF SCIENCE

NORTH CAROLINA DEPARTMENT OF PUBLIC INSTRUCTION

REVISED 1988

Emergency Information

	Phone Number
Rescue Squad	________________
Fire	________________
Police	________________
Hospital	________________
Duke Poison Control Center*	1-800-672-1697

*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
State Department of Public Instruction
Raleigh, NC 27603-1712
(919) 733-3694

Foreword

Safety should be FIRST in the minds of teachers at all grade levels. Hazardous conditions exist wherever science is taught, whether in the classroom or outdoors. It is essential for safety instruction to be an integral part of every science program if we are to provide the safest possible environment for our students. New emphasis in education, such as mainstreaming of handicapped students into regular classes, places new safety concerns on school personnel. Since our courts have become 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 science teacher must be fully aware of the potential hazard(s) associated with any science laboratory or "hands-on" activity. The teacher needs to know appropriate steps to take in case of an accident or emergency. Local education agency administrative staff and principals can give vital support to improving conditions for safer science instruction by providing science teachers with appropriate safety equipment and effective in-service programs.

Schools are encouraged to develop a science safety program. An effective program should include plans for staff development and written safety regulations. This publication, prepared by the Division of Science, is designed to provide current information on science safety matters. It should serve as a useful resource for developing and implementing an effective science safety program.

A. Craig Phillips
State Superintendent of Public Instruction

June 1988

Acknowledgments

Numerous individuals have given support and suggestions in helping to make this publication as informative as possible. We are indebted to everyone who has contributed to this, the third edition, as well as the previous editions.

We wish to express appreciation to a number of individuals who have been most helpful with this edition. We are grateful to Dr. Linda Little of the Governor's Waste Management Board for her longstanding support and advice. We also acknowledge the invaluable assistance of Dr. Ted Taylor, toxicologist with the Department of Human Resources, and Mr. Mercer Doty and Mr. Frank Lewis of the Department of Labor.

We wish to thank Dr. Jack Gerlovich, Iowa Department of Education, for his advice and national leadership efforts on laboratory safety.

Acknowledgment and appreciation is extended to Dr. William E. Spooner for his role as principal author of this publication and for his leadership with the Division of Science's safety program. Appreciation is also extended to our secretarial staff: Linda Edwards for her untiring efforts with the word processor to get the best possible electronic format, and to Linda Page for assisting with editing.

Introduction

"Safety First in Science Teaching" is designed to serve as a resource for teachers and administrators who are responsible for the safety of students in the science program. It is by no means inclusive as safety information is constantly changing and expanding.

This publication should assist science teachers regardless of their background or teaching level. An attempt has been 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 regulations pertaining to safety matters, it is imperative that more emphasis be placed on safety instruction in the science program. The science program may suffer unless adequate safety precautions are taken to protect students and teachers engaged in dangerous laboratory activities. 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 Local Education Agencies (LEAs) 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, State Department of Public Instruction, Raleigh, NC 27603-1712.

Content:

Safety and the Science Program

A science program has 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. Ample opportunities should be available for students to engage in scientific work through laboratory or other "hands-on" activities. Concrete experiences with science are necessary for students if prime results in learning are to occur at the elementary or advanced levels of instruction. Research in science education supports the need for activity-oriented learning in science. Lab work makes it 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.

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[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.

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 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.

A reduction of the frequency and severity of accidents can be accomplished through a positive science safety educational program. Teachers and students must be made aware 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. Many alternative methods are available to replace unsafe procedures. (See Recommended References and Audiovisuals in the Bibliography.) Developing and maintaining positive attitudes toward safety require continual efforts in safety education. Hopefully, safe awareness in the science program will instill in the student the importance of safety in all areas of work and leisure.

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 to protect 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 National Science Teachers Association

[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)

(NSTA) publication, Science Teaching and the Law, by Billye and Walter Brown.[3] Barrett's research also provides an in-depth analysis of liability with sound recommendations.[4]

The Public School Laws of North Carolina specifically deal with required safety devices for eye protection. Article 10, Part 3, "Eye Safety Devices Required," Section 115C-166 through 115C-169 is quoted.

Statute #115C-166. 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. caustic 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 #115C-167. 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 #115C-168. "Industrial-quality eye protective devices" defined.
"Industrial-quality eye protective devices," as used in Section G.S. 115C-166, 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 #115C-169. 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.

NOTE: An excellent film, "Eye and Face Protection in the Chemical Laboratory," is available for purchase or loan from the National Society for the Prevention of Blindness. (See Bibliography--Audiovisuals.)

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[3] Brown, Billye W., and Brown, Walter R. Science Teaching and the Law. Washington, DC: National Science Teachers Association, 1969.

[4] Barrett, Harvey B. "An Analysis of Court Decisions Pertaining to Tort Liability for Student Injuries Sustained in Science Activities in Public School Systems Throughout the United States." Doctoral dissertation, Virginia Polytechnic Institute and State University, 1977.

The Occupational Safety and Health Act of North Carolina (NC 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 NC OSHA applies to science teaching with respect to the employee. 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. Inquires should be addressed directly to the North Carolina Department of Labor, Occupational Safety and Health Division, P.O. Box 27407, Raleigh, NC 27603-1712, phone (919) 733-4880.

Right to Know Law

The Hazardous Chemicals Right To Know Law (G.S. 95-173 et seq.), amended 1987, affects all employers--business, industry, state and local governmental agencies. The purposes of the law are to provide information about hazardous chemicals to fire fighters who must respond to emergencies and to citizens in the community. Key areas in school operations to be surveyed include school buses, vocational shop areas (stored petroleum products, degreasing agents), boiler-custodial rooms (bulk cleaning products), and science labs (evaluated cumulative total quantity stored).

The law exempts laboratories *under direct supervison of a technically qualified person--**provided that labels are maintained on all incoming containers and Material Safety Data Sheets (MSDSs) are maintained and accessible to all employees and students.*** The name(s) and phone number(s) of knowledgeable representative(s) must be given to the fire chief for each facility. For information contact Frank L. Lewis, North Carolina Department of Labor at (919) 733-2658.

Hazard Communication Standard

The Hazard Communication Standard may be referred to as the "Worker Right to Know Law," because it requires employers to train and inform employees about chemicals in the workplace. Key areas for school implementation may include maintenance (school bus, office equipment, custodial) personnel.

Essential requirements include the following:

- written hazard communication program--includes an explanation of container labeling, employee training, MSDS, and a list of hazardous substances in use.

- labels and other forms of information including hazard warnings.

- a Material Safety Data Sheet (MSDS) for each hazardous chemical to which employees are exposed--both physical (flammable, combustible, etc.) and health (carcinogen, irritant, etc.). Hazards are included.

For information contact: Mercer Doty, North Carolina Department of Labor, (919) [illegible]3-2486.

Superfund Amendments and Reauthorization Act (SARA) of 1986

Enacted into federal law on October 17, 1987, SARA requires state/local governments and industry to establish a hazardous chemicals emergency plan. A vital part of SARA is community right to know regarding hazardous and toxic chemicals. Information on hazardous chemicals must be reported to three places: the fire chief, the local Emergency Planning Committee, and to the North Carolina Emergency Response Commission. For information contact your local Emergency Planning Committee or the North Carolina Emergency Response Commission at 1-800-451-1403.

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 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.[5]

- 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. Use of student safety contracts is encouraged.

- 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. This review should include preparing a complete chemical inventory.

- Lab safety in-service is recommended for all science teachers.[6]

<u>NOTE:</u> **The recommendations in this manual are intended to reduce the likelihood of accidents and injury to students and teachers. These recommendations should not be used as an excuse to diminish the amount of instructional time with laboratory or "hands-on" activities. Laboratory activities are designed to facilitate the acquisition of scientific concepts as well as knowledge of the process of conducting scientific inquiry. If certain components of a lab or "hands-on" activity are judged to be too dangerous for today's use, then substituting safer methods and substances should be the guiding rule. There are numerous methods for teaching any scientific concept. Common sense and safety knowledge should be used to render all activities as safe as possible.**

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

[6]A comprehensive staff development program on science laboratory safety is available from the Division of Science, State Department of Public Instruction, Raleigh, NC 27603-1712, (919) 733-3694. Laboratory manuals, films, slides, transparencies, and videotapes to accompany the course are also available.

Laboratory Safety Procedures

Established safety procedures are essential for an 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 all inclusive or "absolutes" and should be interpreted with reason.

Guidelines

The following guidelines can be used as an effective checklist for evaluating the science safety program. A more comprehensive set of evaluative guidelines are available in the computer software program "How to Avoid Being Sued While Teaching Science." [See page 21.]

Another excellent questionnaire for evaluating the safety of a school laboratory is available from Lab Safety Company. It is entitled, Is Your Laboratory A Safe Place To Work? (See Bibliography.)

The National Institute for Occupational Safety and Health's safety course manual, SAFETY IN THE SCHOOL SCIENCE LABORATORY, also contains an excellent 5-page walk-through lab survey. (See Bibliography.)

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 waffling 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, heat-resistant mittens, aprons, 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 forth 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 and gloves should be worn when using corrosive chemicals and at other times when appropriate.

- Never conduct experiments alone in the laboratory.

- Use safety shields or screens whenever there is potential danger of an explosion, implosion, or splashing.

- Proper eye protection devices should be worn at all times in the laboratory by all persons engaged in supervising, performing, or observing science activities.

- 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. Extinguishers must be inspected monthly and records of inspections maintained.

- 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, verifiable 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. Records of face velocities should be maintained.

- Master cutoff valves and 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.

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

First Aid and Emergency Tips

- Know first aid procedures.
- 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.
- Display emergency phone numbers.
- Material Safety Data Sheets should be readily available for all chemicals in the laboratory.

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 hand-held 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 and containers 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, remove the cooker from the heat source, 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.

- Scalpels or cutting devices should be sterilized prior to and after use to prevent infection from accidental cuts.

- Under no condition should potassium or sodium cyanide be used as the killing agent in insect-killing jars. If alcohol or ethylacetate 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.

- Use a water bath when heating alcohol. The alcohol container top should be below the top of the water-bath container.

- Volatile and flammable liquids such as alcohol should be used in very small quantities away from open flames and in a well-ventilated room. Such substances should be heated with hot plates 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 ceramic-centered wire gauze.

- Do not pour water into acid. (DO WHAT YOU "OUGHTA" [ought to], PUT THE ACID IN THE WATER!)

- 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 with at least six complete air exchanges per hour.

  - Keep the liquid over a pan or sink.

  - Use no flames or high-temperature heating devices.

  - Do not store in or around a home-type refrigerator. Fumes inside or outside the refrigerator may be ignited by sparks produced in the electrical switching system. (Explosion-proof refrigerators are available from science supply houses.)

  - Use only approved containers for storing flammables. Make sure containers are labeled.

  - Limit the volume used to the smallest amount possible.

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 only 3-prong service outlets.

- Electrical equipment must 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 must 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 safety items needed in the science laboratory:

- fire extinguishers*

- first aid kits
- fire blankets (non-asbestos-types)
- sand buckets
- eyewash facilities
- emergency shower facilities
- safety goggles or face shields
- laboratory aprons
- gloves (non-asbestos-types for handling hot materials)
- tongs
- respirators
- wire gauze and/or ceramic-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 rbonaceous 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 for Class "A," "B," and "C" fires.

- 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 with a scoop. Dry sand may also be used to extinguish small class "D" fires. Apply the dry chemical directly onto the burning area with a scoop. Completely cover the fire source.

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.[2] 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 whiskbroom 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. Remember, hot glass looks the same as cold glass.

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.

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

Cutting

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

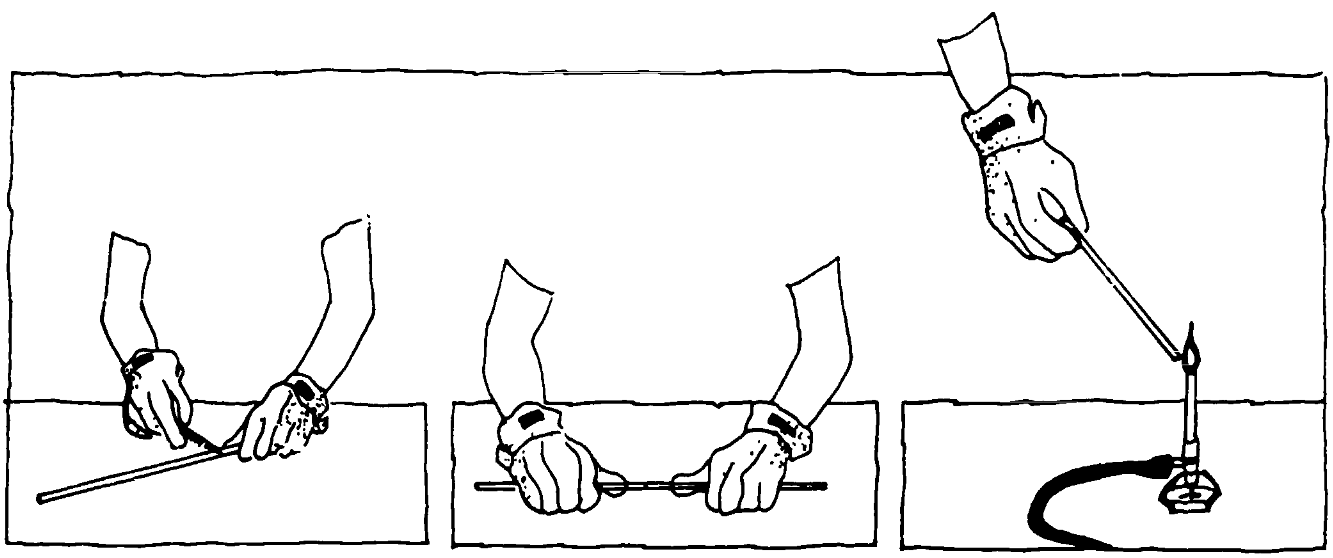
1. Lay the tubing on a flat surface and hold it firmly in place with hand at the approximate position where the break is to be made.

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.

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 at an angle.

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 a heat-resistant mat or some other insulation material while it cools. Always place the "hot" end away from the counter top.

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 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 a heat-resistant 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 closely as possible to the stopper. Always aim the rod or tubing <u>away</u> 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 single-edge razor blade or knife and then reclosing them with rubber glue.

Chemical Management

It is important for schools to have a well, thought-out and coordinated plan for chemical management. New laws/regulations, as well as public concern for protecting our health and environment, make sound chemical management an essential element of the science program. A plan should address purchasing, storage, and disposal procedures, as well as utilization practices.

More than 20,000 chemical compounds may pose some kind of potential risk to human health and the environment. Many chemicals used in instructional programs are known or suspected carcinogens (capable of causing cancer), neoplastics (capable of producing noncancerous tumors), and teratogens (capable of causing birth defects). Some chemicals are highly toxic or may cause severe allergic reactions; others are capable of causing body injury by their explosive or combustible nature. A 1984 study, conducted by the Science Division, revealed that over 500 chemicals were associated with the science instructional program. More than half of these substances were judged to be too hazardous to justify for instructional purposes.

School science personnel must be well informed about currently acceptable safety standards as well as laws and regulations. Adequate safety equipment and reference materials are essential. Safety knowledge put into practice can greatly reduce the frequency and severity of injuries as well as reduce the likelihood of liabilities.

Inventory

A chemical inventory is a basic component of a sound chemical management program. Compiling an accurate inventory is the first step needed in order to determine the status and specific goals associated with chemical management.

State and federal laws/regulations require schools to maintain inventories under certain conditions. In North Carolina, the Right to Know Law, the Hazard Communications Standard, and the Superfund Amendments and Reauthorization Act may impact upon schools that use certain hazardous chemicals. (See Department of Labor, p. 4.)

Preparing a chemical inventory can be very time consuming. Personnel responsible for compiling an inventory should follow common sense in respect to safety practices. These practices include use of safety equipment such as gloves, safety glasses, and protective clothing. A fire extinguisher should be available. In some cases a respirator may be required where concentrations of organic or inorganic vapors are high. Personnel should never work alone and should not work for long periods at a time.

Personnel compiling an inventory should be prepared for finding unexpected substances which might be explosive, highly flammable, highly toxic, or unlabeled. If uncertainties arise about how such items should be handled, then expert advice should be sought prior to attempting to remove or dispose of such items.

Once the inventory is compiled, all items should be carefully evaluated to determine if they can be justified for safe use in the school environment. Appropriate references and Material Safety Data Sheets (MSDSs) will be needed for evaluating the inventory.

Copies of the inventory should be on file with each teacher who uses chemicals, the school principal, and the administrative office. The inventory should be up-dated regularly and no less than annually.

The chemical inventory should contain as much pertinent information as possible. The following information should be considered essential.

1. School name, address, telephone number
2. Name of person(s) compiling inventory
3. Date of inventory
4. Alphabetical listing of all chemicals
5. Amount
6. Storage location (room number)
7. Storage category (based on chemical compatibilities)
8. Hazardous class information
9. Date purchased

Currently available computer inventory systems can greatly facilitate compilation and the maintenance of an inventory, especially if the list is more than several pages in length. Several computer systems have been designed primarily for secondary school use and contain files listing 400-900 of the most commonly found substances. Files can be easily customized by addition or deletion of items. Essential safety information is also provided as a part of the computer inventory systems.

"How to Avoid Being Sued While Teaching Science" is an example of an excellent software program. It was developed by a science educator who is also a nationally recognized school safety expert. The three disk system provides: 1) a 56-page safety manual (copyright 1987); 2) numerous safety forms and a lengthy safety checklist for evaluating a school safety program; 3) an inventory system containing 423 commonly used chemicals with pertinent safety data.

The chemical list can easily be expanded or reduced to give a customized inventory list. The inventory system includes a variety of safety-information, such as other names, storage categories, hazard class, and National Fire Protection Association (NFPA) ratings. Chemical labels can also be printed. The storage location, including room number and shelf location, quantity, and expiration date can be designated for each substance on the list. Search and sort features are also incorporated.

Two commercial suppliers are currently selling this safety program. They are: NASCO (1-800-558-9595) and Lab Safety Supply Co. (1-800-356-0783). The program sells for less than $50.00.

"Cheminventory" is an inventory system produced by Flinn Scientific, Inc. and has a data base of 952 substances. This program provides similar features as listed in the above program as well as several additional characteristics such as substrate, CAS numbers, grade, and disposal methods. This program is currently priced at $180.00. The address and telephone number are: Flinn Scientific, Inc., P.O. Box 219, Batavia, IL 60510, (312) 879-6900.

Chemical Storage Facilities

Storage facilities should provide protection from fire, exposure (human and environment), and criminal acts. Proper storage policies are essential to the safe operation of any laboratory. The most common malpractice with chemical storage is the use of an alphabetical system. Such storage procedures may allow incompatible che-nicals to interact. (See Incompatible Chemicals on p. 28.) Proper storage arrangement allows compatible chemicals of the same class to be stored together.

Below are some precautions regarding storage of chemicals which should be considered:

- Laboratory chemicals and equipment should not be stored in the same room.
- Cleanliness and order should be maintained in the storage area at all times.
- Storage rooms containing flammable, toxic, or combustible substances must be properly ventilated and lighted.
- The chemical storage area must be secured at all times when not in use, with access only to authorized personnel.
- Flammables, acids, and lightly toxic substances should be stored in locked safety cabinets.
- Flammable or toxic gases should be stored at or above ground level and not in basements.
- All gas cylinders must be secured against falling over and be stored away from heat sources.
- All chemicals must be adequately labeled and stored alphabetically according to compatibility types. Traditional alphabetical storage is unsafe.
- Mixing or transferring chemicals should not be permitted in the storage area.
- Open flame, smoking, or any other type of heat must not be permitted in the chemical storage area(s).
- Chemical storage shelves should have raised (lip) edges.
- Chemical shelving should be constructed of wood.
- Chemicals should not be stored above eye level.
- All chemical shelving should be attached to walls.
- Fume hoods must not be used for chemical storage.

- Store large chemical containers on or near the floor.

- Electrical equipment and outlets in the storage area must be well-grounded.

- When needed, use explosion-proof refrigerators in storage areas containing flammable or combustible substances. Such substances should not be stored in a regular type refrigerator.

- Do not store chemicals that are not currently being used in the approved instructional program. (See Chemical Disposal on p. 36.)

- A fire extinguisher should be immediately accessible. (The multipurpose-type covers class A, B, and C fires. A sand bucket may be required for class D fires.)

- NOTE: For specific data on storage information relating to the above statements, see the National Institute for Occupational Safety and Health manual entitled SAFETY IN THE SCHOOL SCIENCE LABORATORY. (See Recommended Reference List.)

SUGGESTED CHEMICAL STORAGE PATTERN*

Storage of laboratory chemicals presents an ongoing safety hazard for school science departments. There are many chemicals that are incompatible with each other. The common method of storing these products in alphabetical order sometimes results in incompatible neighbors. For example, storing strong oxidizing materials next to organic chemicals can present a hazard.

A possible solution is to separate chemicals into their organic and inorganic families and then to further divide the materials into related and compatible families. Below is a list of compatible families. On the next page you will find this family arrangement pictured as shelf areas in your chemical storage area. The pictured shelf arrangement will easily enable you to rearrange your inventory into a safer and more compatible environment.

INORGANIC

1. Metals, Hydrides
2. Halides, Sulfates, Sulfites, Thiosulfates, Phosphates,
3. Amides, Nitrates, (Except Ammonium Nitrate), Nitrites, Azides, Nitric Acid
4. Hydroxides, Oxides, Silicates, Carbonates, Carbon
5. Sulfides, Selenides, Phosphides, Carbides, Nitrides
6. Chlorates, Perchlorates, Perchloric Acid, Chlorites, Hypochlorites, Per- ox es, Hydrogen Peroxide
7. Arsenates, Cyanides, Cyanales
8. Borates, Chromates, Manganates, Permanganates
9. Acids (Except Nitric)
10. Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide

ORGANIC

1. Acids, Anhydrides, Peracids
2. Alcohols, Glycols, Amines, Amides, Imines, Inides
3. Hydrocarbons, Esters, Aldehydes
4. Ethers, Ketones, Ketenes, Halogenated Hydrocarbons, Ethylene Oxide
5. Epoxy Compounds, Isocyanates
6. Peroxides, Hydroperoxides, Azides
7. Sulfides, Polysulfides, Sulfoxides, Nitriles
8. Phenols, Cresols

NOTE: If you store volatile materials (ether, hydrocarbons, etc.) in a refrigerator, the refrigerator must be explosion-proof. The thermostat switch or light switch in a standard refrigerator may spark and set off the volatile fumes in a refrigerator and thus cause an explosion.

Surely this list is not complete and is intended only to cover the materials possibly found in an average school situation. This is not the only method of arranging these materials and is purely suggested.

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SUGGESTED SHELF STORAGE PATTERN*

INORGANIC TOP	ORGANIC TOP
INORGANIC #10 Sulfur, Phosphorus, Arsenic, Phosphorus Pentoxide	**ORGANIC #2** Alcohols, Glycols, Etc. (Store flammables in a dedicated cabinet)
INORGANIC #2 Halides, Sulfates, Sulfites Thiosulfates, Phosphates, Etc.	**ORGANIC #3** Hydrocarbons, Esters, Etc. (Store flammables in a dedicated cabinet)
INORGANIC #3 Amides, Nitrates, (Not Ammonium Nitrate), Nitrites, Etc.	**ORGANIC #4** Ethers, Ketones, Etc. (Store flammables in a dedicated cabinet)
INORGANIC #1 Metals & Hydrides (Store away from any water)	**ORGANIC #5** Epoxy Compounds, Isocyanates
INORGANIC #4 Hydroxides, Oxides, Silicates, Etc.	**ORGANIC #7** Sulfides, Polysulfides, Etc.
INORGANIC #7 Arsenates, Cyanides, Etc. (Store above acids)	**ORGANIC #8** Phenol, Cresols
INORGANIC #5 Sulfides, Selenides, Phosphides, Carbides, Nitrides, Etc.	**ORGANIC #6** Peroxides, Azides, Etc.
INORGANIC #8 Borates, Chromates, Manganates, Permanganates, Etc.	**ORGANIC #1** Acids, Anhydrides, Peracids, Etc.
INORGANIC #6 Chlorates, Perchlorates, Chlorites, Perchloric Acid, Peroxides, Etc.	**MISCELLANEOUS**
INORGANIC #9 Acids, except Nitric (Acids are best stored in dedicated cabinets)	**MISCELLANEOUS** (Nitric Acid)

If possible avoid using the floor. All poisons must be in locked cabinets.

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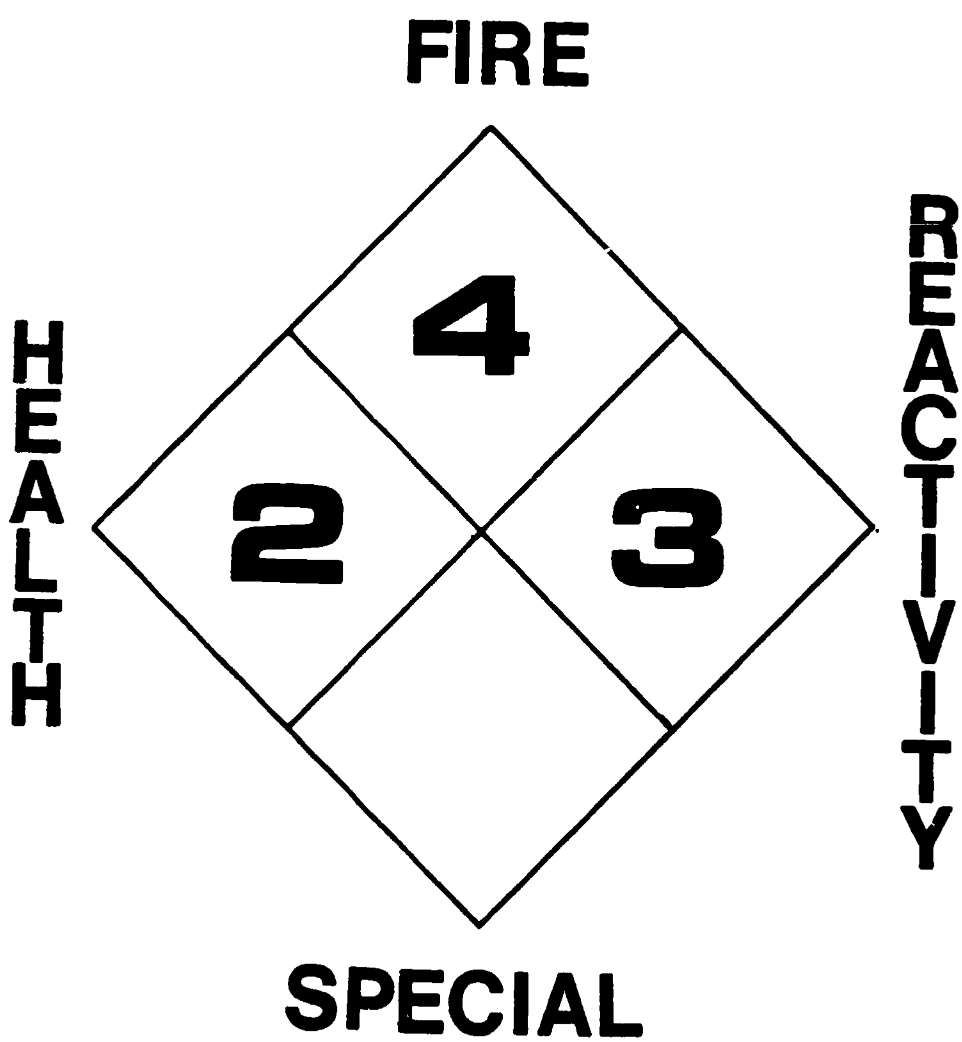
Chemical Labels

Each chemical container must be properly identified. The label should provide accurate information listing the chemical name, purchase date, manufacturer or supplier, and precautionary information. An excellent hazardous coding system, developed by the National Fire Protection Association, is explained in their publication entitled FIRE HAZARDS OF MATERIALS (#704). The NIOSH safety manual, "SAFETY IN THE SCHOOL SCIENCE LABORATORY," provides information on the coding system and contains a chapter on "Labeling." (See Recommended Reference List.)

HAZARD DIAGRAM



Identification of Health Hazard Color Code: BLUE		Identification of Flammability Color Code: RED		Identification of Reactivity (Stability) Color Code: YELLOW	
Signal	Type of Possible Injury	Signal	Susceptibility of Materials to Burning	Signal	Susceptibility to Release of Energy
4	Materials which on every short explosure could cause death or major residual injury even though prompt medical treatment were given.	4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readilly.	4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures
3	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given.	3	Liquids and solids that can be ignited under almost all ambient temperature conditions.	3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.	2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given.	1	Materials that must be preheated before ignition can occur.	1	Materials which in themselves are normally stable, but which can become unstable at eleveated temperatures and pressures or which may react with water with some release of energy but not violently.
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.	0	Materials that will not burn.	0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

Incompatible Chemicals

The previously suggested storage pattern is designed to prevent incompatible chemicals from interacting. The following is a partial listing of incompatible substances. The chemicals listed in the left column should be stored in a manner that will prevent them from coming in contact with those in the right 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, oxygen, fluorine, copper tubing, 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

Procurement of Chemicals

In past years schools have collected and stock-piled chemicals through many sources including, NDEA, federal surplus, and through gifts from colleges and industry. In most cases, no consideration was given to how the substances were to be used. Neither were substances screened for toxicity or being hazardous. Chemicals were acquired in large quantities with no knowledge of their date of manufacture or technical data. Such procurement practices have caused, to a great extent, major health and disposal problems which we must now bear the responsibility for correcting.

The following procurement practices are recommended.

- Purchase orders should be carefully screened by a school system safety committee for toxic and hazardous substances. Proper justification should be required before such substances are ordered.

  Justification should consider:

  1. Personnel are qualified and knowledgeable about the substance and its safe use.
  2. References or Material Safety Data Sheets (MSDSs) are available and consulted in the justification process.
  3. Proper safety equipment is available and used.
  4. The substance is an essential requirement for the science program or activity.
  5. Justification, in some cases, should be limited to specific courses under the directions of a specified teacher(s).

- Purchase only enough chemicals for one school year. Bulk purchasing is not recommended.

- Purchase only chemicals that are needed to support the approved instructional program.

- Be knowledgeable of the technical and safety data of all chemicals purchased.

- Request and maintain Material Safety Data Sheets (MSDSs) on all chemicals.

- Record the "date received" on the label of all chemicals as well as on the chemical inventory.

- Do not stockpile chemicals.

Recommendations on Using Hazardous Substances

Numerous state and national organizations have published lists of hazardous substances not recommended for general school use. The intent of such lists is good; however, listings are misinterpreted and grossly misused. Such lists are outdated almost as soon as they are published. Many schools elect to take the easy way out of the dilemma by disposing of any substance that appears on a list(s). The sense of security gained from this approach is short lived as the lists change constantly. The 1977 and 1983 editions of this manual are good examples of this dilemma. Current recommendations for making sound judgment on selecting and restricting chemicals in the science program take into consideration the following:

- Hazardous data on chemical substances continue to be updated.
- New laws and regulations shift the burden of responsibility for managing hazardous substances to the user.
- New safety equipment and technical reference data are widely available.
- Science textbooks are incorporating safer laboratory activities as well as providing more safety information.
- Comprehensive laboratory safety training for science teachers has been widely available. A majority of science teachers in North Carolina have participated in safety staff development programs at the state, regional, and local levels since 1979.
- New chemistry programs are available that use a micro-scale approach. This approach reduces, by an average factor of 100, the amount of chemicals used in an experiment. Special micro-scale glassware greatly reduce exposure making some previously unacceptable lab activities safer.

In the final analysis, the user (qualified science teacher) is responsible for deciding which substances can be safely employed in instructional or research activities. This decision is best made by a collective process involving the science faculty and administrative staff. The decision making process should include the following factors.

1. Grade level: Some substances may not be justifiable for use at the elementary school level by teachers with little or no science background. The same substances may be justifiable for limited or restricted use in the middle grade science program. The high school chemistry or biology

program may have no difficulty justifying substances that are banned at the elementary level and restricted in the middle grades.

2. Course type: The type of science course is also a factor in deciding usefulness of chemical substances. Some advanced courses may justifiably use substances that cannot be safely used in basic courses. The maturity level of students enrolled in different type courses is a factor to consider.

3. Facilities/Equipment: The facility and availability of appropriate safety equipment must be considered when deciding if certain substances can be safely used. Some laboratory activities may require good ventilation, safety glasses, aprons, gloves, etc. Without appropriate facilities and equipment, including safety data information, some substances are difficult to justify for school use.

4. Teacher Qualifications: Science teachers need to be appropriately certified and qualified in order to safely use some chemical substances. Teacher background is most important at the high school and middle school levels. Ninety percent of the chemicals associated with the science program are found at the high school level. Approximately eight percent are used in the middle grades.

Each chemical must be carefully evaluated for acceptability by using current and accurate technical data while considering the above mentioned factors. One source for technical data is provided in a Material Safety Data Sheet (MSDS).

NOTE: It is strongly recommended that a Material Safety Data Sheet be maintained for each chemical used in the science program. In some cases, MSDSs are required by law. State law also requires chemical suppliers to provide MSDSs for chemicals purchased since May, 1986. School personnel should request Material Safety Data Sheets with all chemical orders.

The MSDS should be maintained at the sight of storage. Pertinent information on the characteristics and hazards associated with any chemical should be studied by the teacher and shared with students prior to use.

Sources for Safety Data Information

Material safety data information is available from numerous sources. Chemical suppliers may sell Material Safety Data Sheets for individual substances or by total volume sets. Suppliers are required to provide Material Safety Data Sheets for hazardous chemicals sold in North Carolina.

The following are several sources for safety data information:

1. *"Hazardous Chemical Data Book,"* catalog number 31975, is a 1200-page document containing data and Material Safety Data Sheets for over 1400 chemicals. It should serve as a basic reference for most all chemicals associated with school use. The 1988 price is $119.00 plus $5.14 for shipping and handling. The source is Central Scientific Company, 11222 Melrose Avenue, Franklin Park, IL 60131, (312) 451-0150.

2. *"Chemical Hazard Response Information System (CHRIS): Hazardous Chemical Data"* (Document number 050-012-00215-1) is a primary source of information from which many other commercial sources obtain data for Material Safety Data Sheets. This publication contains information on over 1000 substances including chemical properties, health and fire hazards, chemical reactivity, water pollution, shipping and labeling requirements, and first aid information.

   The "CHRIS" publication is available from the Superintendent of Documents. The total cost is $41.00. Payment must accompany all orders. Request by name and document number from the Superintendent of Documents, United States Government Printing Office, Washington, DC 20402-9325.

Microcomputer software and CD-ROM systems are available for material safety data information. However, at this time these systems are designed for industry and are very expensive.

Which chemicals should not be used in the school science program? There is not a simple answer to this question. Any substance can safely be used under the right conditions. In the final analysis, it is the user's responsibility to decide if a substance poses a greater risk than educational benefit. The user must have technical data, as provided in Material Safety Data Sheets, in order to make sound decisions. This decision should also consider previously discussed suggestions in this chapter.

The following are general recommendations for classes of chemicals . should be considered inappropriate for use in the science program.

- Known or suspected human carcinogens
- Explosives
- Substances with a health, fire, or reactivity rating of 3 or 4 (A rating code used by the National Fire Protection Association [NFPA]. NOTE: Many substances

have not been rated by the NFPA. Material Safety Data Sheets usually provide this rating when known.)

- Mutagens, teratogens, highly toxic or corrosive substances (These substances should be carefully evaluated before approval for school use.)

Three essential rules must be followed when making decisions on safe chemical usage. They are:

1. Know what you have. (Inventory)
2. Know if it can be safely used. (Technical data and conditions for use)
3. Dispose of substances not needed or justifiable for school use. (Disposal plan)

The following are common examples of known or suspected carcinogens and explosives associated with the school science program.

KNOWN CARCINOGENS

<u>CAUTION</u>: This is not a comprehensive list. The source is "School Science Laboratories: A Guide to Some Hazardous Substances," 1984. (See Booklets--Bibliography.)

1. Arsenic Powder*
2. Arsenic Pentoxide
3. Arsenic Trichloride
4. Arsenic Trioxide
5. Asbestos
6. Benzene
7. Benzidine
8. Chromium Powder*
9. Chromium (VI) Oxide
10. Lead Arsenate
11. Sodium Arsenate
12. Sodium Arsenite

PROBABLE CARCINOGENS

<u>CAUTION</u>: This is not a comprehensive list. The source is "School Science Laboratories: A Guide to Some Hazardous Substances," 1984. (See Booklets--Bibliography.)

1. Acrylonitrile
2. Cadmium Powder*
3. Cadmium Chloride
4. Cadmium Sulfate

5. Carbon Tetrachloride
6. Chloroform
7. Ethylene Oxide
8. Nickel Powder*
9. o-Toluidine

*Evidence for the carcinogenicity of these metals is derived from occupational exposure studies. Although it is uncertain whether the metal compound(s) is responsible, only respirable particulates are thought to be of concern.

EXPLOSIVES

CAUTION: This is not a comprehensive list of all possible explosive chemicals.

1. Benzoyl Peroxide
2. Carbon Disulfide[1]
3. Diisopropyl Ether[2]
4. Ethyl Ether[2]
5. Picric Acid[3]
6. Perchloric Acid[4]
7. Potassium metal[2]

There are several major sources for current information on hazardous substances. Probably the most efficient procedure for evaluation of a chemical inventory is to obtain a Material Safety Data Sheet for each substance. Two resources for MSDSs have previously been mentioned in this section.

Data on carcinogens are compiled by at least four governmental agencies. The International Agency for Research on Cancer (IARC), The National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the American Conference of Governmental Industrial Hygienists (ACGIH) all evaluate chemicals for carcinogenic effects. A report of this

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[1]The flashpoint of carbon disulfide (-22° F) is well below room temperature and small amounts of the vapor in the air can be explosive.

[2]These chemicals become dangerous upon aging. Ethers and potassium metal can both form explosive peroxides upon exposure to air. Old opened containers of ether should be treated with great caution as should potassium metal not stored under kerosene.

[3]Picric acid should always contain 10-20% water and bottles should be disposed of after two years. Dry picric acid is explosive.

[4]Although the 70% acid/water mixture is not explosive by itself, the use of perchloric acid often leads to the formation of perchlorates which are very explosive.

research is periodically published by the National Technical Information Service. The last "Fourth Annual Report on Carcinogens" was published in 1985. A summary of this report is available from the National Toxicology Program, Public Information Office, MD B2-04, Box 12233, Research Triangle Park, NC 27709, (919) 541-3991.

The Division of Emergency Management may be able to provide data on many hazardous substances. Every county in North Carolina has a local office. The Raleigh office can be contacted by phone at (919) 733-3867.

The Department of Labor may also be of assistance with current listings of hazardous substances. Contact Mercer Doty at (919) 733-2486 or Frank Lewis at (919) 733-2658.

The 1984 publication, "School Science Laboratories - A Guide To Some Hazardous Substances," may be of value when making decisions on chemical usage. It has been widely distributed to schools in North Carolina and is available from the Science Division. The categorical lists provided in this document should not be used as the only source when making decisions about safe chemical usage.

Chemical Disposal

Most schools have accumulated a wide assortment of chemicals over a period of many years. A high percentage of these substances are likely to be very hazardous, no longer needed, unlabeled, or contaminated. They should be properly identified and safely removed from the school environment.

Chemical waste will continue to be generated in the normal operation of the science instructional program. This waste must also be periodically removed from the school premises.

The process of disposing of chemicals and chemical waste is becoming more complex and costly each year. There is not an easy or quick method to safely dispose of chemical substances. Each school and school system must have a well-thought-out plan in order to remove hazardous substances from the school environment. A disposal plan may require one to two years to fully implement. Some hazardous substances designated for disposal may not be accepted by a commercial hazardous waste transporter. In this case, these substances must be stored safely until appropriate disposal means are available.

Disposal Priorities

The following priority action steps are recommended for disposing of chemicals and hazardous waste.

Phase I.	Identification/Storage	Each chemical must be evaluated in terms of its acceptability for use in the science program. Appropriate references and Material Safety Data Sheets should be consulted. Acceptable substances should be store properly according to compatible categories. (See page 25.) Items designated for disposal should be tagged and stored appropriately. If items designated for disposal are to be stored separately, then they should also be stored according to compatible types.
Phase II.	Disposal	Each chemical or class of chemicals should be evaluated for the most appropriate and efficient disposal method beginning with Priority 1. If disposal funds are no problem, go directly to Priority 3.

Priority 1 - Reuse/Recycle

Considering the high price of chemicals, every effort should be made to recycle or reuse the substance. The substance can be given or sold to institutions, organizations, or individuals who need and can safely use it. In some cases hazardous substances may be moved from an elementary or middle school to a high school where it can be used safely.

Contact local industries, colleges, or schools to determine if they can safely use items on your disposal list. In some cases, the chemical supplier may be able to help.

A waste exchange program is available from Southeast Waste Exchange, The Urban Institute, The University of North Carolina at Charlotte, UNCC Station, Charlotte, NC 28223, phone (704) 597-2307.

Priority 2 - In-House Treatment and Disposal

If substances remain after *Priority 1* has been executed, then in-house methods can be employed. It is estimated that many substances found in schools can be safely rendered harmless and disposed of at the school site. These procedures can be implemented by a qualified chemistry teacher.

A valuable source listing disposal procedures for over 1,000 subtances is found in the GUIDE FOR SAFETY IN THE CHEMICAL LABORATORY. (See Books--Bibliography.) In addition, valuable information is provided on general safety. Physical and chemical properties, health, fire, and reactivity ratings of many chemicals are also listed. Free chemical catalogs listing storage and disposal procedures are available from the Aldrich Chemical Company and Flinn Scientific, Inc. Both are valuable resources. (See Catalogs--Bibliography.)

"Prudent Practices For Disposal of Chemicals from Laboratories" by the National Academic Press is recommended for personnel with a strong chemistry background who wish to learn specific procedures for chemical disposal. (See Reference List.)

Priority 3 - Hazardous Waste Management Facility

Chemicals that remain after Priorities 1 and 2 have been exhausted should be handled by a hazardous waste transporter. Schools can contract with hazardous waste transporters to pick-up and transport hazardous substances to a hazardous waste facility. This procedure is expensive. Cost to LEAs in North Carolina has been as much as $3,500.00. A recent estimate for removing 12 boxes of chemicals from a small school system was $8,000.00. It should be noted that commercial agencies will not dispose of all hazardous waste. There are items that may not be accepted in a hazardous waste facility or by a transporter. Examples may include explosives, banned products, gases, and pesticides.

The following hazardous waste transporters have been of service to schools throughout North Carolina. If you have chemicals that are in need of disposal through commercial vendors, you may wish to obtain several estimates prior to contracting.

ECO-FLO
P.O. Box 10383
Greensboro, NC 27404
(919) 855-7925

Enviro-Chem Waste
Management Services
1005 Investment Ave.
Apex, NC 27502
(919) 362-9010

GSX Services, Inc.
Route 1
Watlington Industrial Rd.
Reidsville, NC 27320
(919) 342-6106

It is important that an inventory of all chemicals designated for disposal be prepared prior to calling a hazardous waste transporter. Most transporters usually want to know the amount of each item. Unknowns are a problem in that each unknown must be identified through chemical analysis before it can be disposed. Chemical analysis may cost as must as $50.00 per bottle. Note: Do not expect a hazardous waste transporter to handle all of your hazardous materials. Each transporter has a list of certain items they will not accept.

In addition to commercial agencies, disposal help has been given by local fire or police departments. Military bases have also assisted schools. Several state agencies have given assistance with special chemicals such as picric acid. Call the Science Division for more information.

Lab Manuals and Textbooks

It should never be assumed that science texts and laboratory manuals contain safe experiments. All printed instructional material should be carefully evaluated for possible safety hazards.

A study of 10 major chemistry laboratory manuals revealed an average of 683 potential health hazards. Chemicals capable of causing death or permanent injury on brief exposure, or being carcinogenic, average 47 per book. Chemicals capable of causing permanent damage on long exposure, or injury on brief exposure, averaged 83 per book.[5]

Common sense along with current safety knowledge should be used to render all activities as safe as possible. We should remind ourselves that any substance can be hazardous if used improperly. Common chemicals such as water or table salt can cause serious health consequences if used incorrectly. Many hazardous substances that are being removed from the schools are used daily in the home environment with NO or little concern.

Three general rules should be considered when hazardous and toxic chemicals are to be used.

Rule I: Find a safer substitute. The Manual of Safety and Health Hazards in the School Science Laboratory provides such suggestions. (See Recommended References and Audiovisuals.)

Rule II: Restrict the amount of chemical reagent used. Do not use 100 ml of a reagent when 5 ml will show the same results.

Rule III: Dilute the reagents. Many reactions will work with diluted reagents. Do not expose yourself or students to concentrated substances unless absolutely necessary.

Mercury

Known since ancient times as quicksilver, mercury has a long history of use in the science curriculum. Most adults can remember "playing" with mercury in the science lab and making shiny coins. It is now recognized as a two-headed monster.

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[5]Singh, Karan. "Toxic Effects of Chemical Substances in High School Chemistry Laboratories." An unpublished doctoral dissertation, University of Cincinnati, 1981.

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.

Producing mercury vapor is a major health concern in the school laboratory. Because of its high volatility, mercury (in element form) when dropped, breaks into a "zillion" small droplets. The surface area is greatly increased when small droplets are formed and thus, the amount of mercury vapor increases proportionately. For example, a teaspoonful of mercury covers an area of about 10 cm^2. This surface area of mercury will vaporize at normal room temperature, in still air, at a rate of 0.007 mg/hr. Under such conditions, a room three meters high covering an area of seven square meters will reach dangerous vapor levels in two weeks. Federal and state regulations limit continuous exposure to mercury vapor to 0.1 mg per cubic meter of air.

Dropping mercury on floors, especially wooden floors, with many cracks and crevices, greatly increases 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.

An emergency response squad was recently summoned to a North Carolina junior high school to cleanup a mercury spill. The accident occured when a student brought mercury from home. In 1986, 22 students and their teacher were exposed to high levels of mercury vapor. Mercuric oxide was inadverently substituted in an oxidation reduction experiment that called for silver oxide. Student exposure was estimated at 9.3 mg. One year later, all students still had mercury in their system. The biological half-life for mercury ranges from 35 to 90 days.[6]

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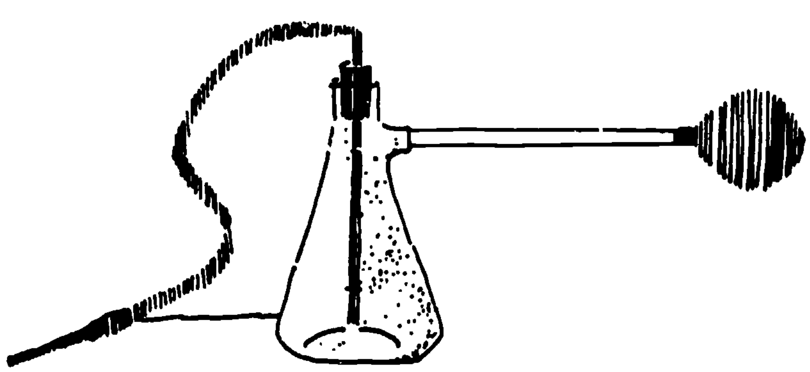
[6]"Mercury Exposure in a High School Laboratory - Connecticut." Morbidity and Mortality Weekly Report. Center for Disease Control, United States Department of Health and Human Services, March 18, 1988/Vol. 37, No. 10.

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 is not recommended for school use.
- 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. Attach a fine pipette or capillary tube to the spout tube. Very small droplets can be vacuumed into the wash bottle. (See illustration.)

- 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 smooth surfaces can be cleaned up with a suspension made from 250 ml of liquid detergent, 250 ml of sulfur, and one liter 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: Clean up assistance or mercury vapor surveys can be obtained by contacting the North Carolina Department of Human Resources, Occupational Health, P. O. Box 2091, Raleigh, NC 27601, (919) 733-3680.

Dangerous Substances and Reactions

New hazards are constantly being recognized with chemical substances and reactions that were once considered safe. The following is a partial listing of such substances and reactions.

General

- 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. *This demonstration is not recommended.*

- 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. Carbon tetrachloride is among most school laboratory chemical supplies. It should never be used as a fire extinguishing medium or as an agent in insect-killing containers. *It is not recommended for school use.*

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

- 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 in each hood compartment. 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. A special respirator must be easily accessible. All potential users must be thoroughly trained in its use. *Chlorine experiments are not recommended.*

- Chromate cleaning solutions *are too hazardous for school use.* A recommended substitute is "Micro" manufactured by the Cole-Parmor Instrument Company, 7425 North Oak Park Avenue, Chicago, IL 60648. It is biodegradable, has a very low toxicity rating, and does an excellent job in cleaning glassware.

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

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

- Magnesium ribbon burning experiments are spectacular. However, the intense radiation (light, ultraviolet) given off can damage the eyes. This demonstration can be safely performed if the burning magnesium is lowered into a large tin can. The room lights should be turned off. The intense light is projected to the ceiling. The effects are dramatic. The production of oxidation can be examined immediately afterwards. *Direct viewing of burning magnesium is not recommended.*

- Mercuric oxide decomposition experiments *are not recommended.* Mercury vapor is very toxic and the effects are accumulative when absorbed by the body. (See section on Mercury.)

- Picric acid (trinitrophenol), an explosive more powerful than TNT, was reported found in 35 North Carolina LEAs in 1979. If this substance is found in the school chemical supply, it should be disposed. Only qualified personnel should carry out this procedure. Contact the Division of Science for information on disposal sources. *It is recommended that this compound not be used or stored.*

- 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. *It is not recommended for school use.*

- Potassium permanganate/acid volcano demonstrations *are not recommended.* These firework displays are not realistic and should be considered too hazardous for school use. A more realistic approach would be to use a color film showing actual volcanic eruptions. Baking soda and vinegar can be used as a relatively safe demonstration.

- 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 taste 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.

Science and Laboratory Activities

Safe laboratory and other science-related activities are an essential part 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 natural phenomena is to observe them in their own peculiar setting. A field trip should 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 waste good instructional time and set the stage for potential accidents. In addition to having well-stated educational objectives, including pre-trip 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.

- Instruct students fully 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.

- 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."

<u>Poisonous Plants</u>

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 ill and some die. In many cases, teachers and parents are not aware of the dangers associated with plants.

There are over 700 plant species known to cause illness or death. Students need to be made aware of the potential dangers associated with plants encountered on field trips or in the science classroom. The following is a list of common poisonous plants.[1]

[House Plants]

Plant	Toxic Part(s)	Symptoms and/or Consequences
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]

Plant	Toxic Part(s)	Symptoms and/or Consequences
Larkspur	Young plant, seeds	Digestive upset, nervous excitement, depression. May be fatal.
Monkshood	Fleshy roots	Digestive upset and nervous excitement.

[1]Seder, Susan. "A New Look At Poisonous Plants." Family Safety Magazine, Vol. 31, No. 1, Chicago, 1972.

[Flower Garden Plants] (cont.)

Plant	Toxic Part(s)	Symptoms and/or Consequences
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 and/or Consequences
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 and/or Consequences
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.

Plant	Toxic Part(s)	Symptoms and/or Consequences
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.
Jasmine	Berries	Fatal. Digestive disturbance and nervous symptoms.
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 and/or Consequences
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.
Elderberry	Shoots, leaves, bark	Children have been poisoned by using pieces of the pithy stems for blowguns. Nausea and digestive upset.
Black locust	All parts	Children have suffered nausea, weakness, and depression after chewing the bark and seeds.

[Wooded Area Plants]

Plant	Toxic Part(s)	Symptoms and/or Consequences
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 system.
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 you know it is absolutely safe.
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(s).
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.

[Resource]

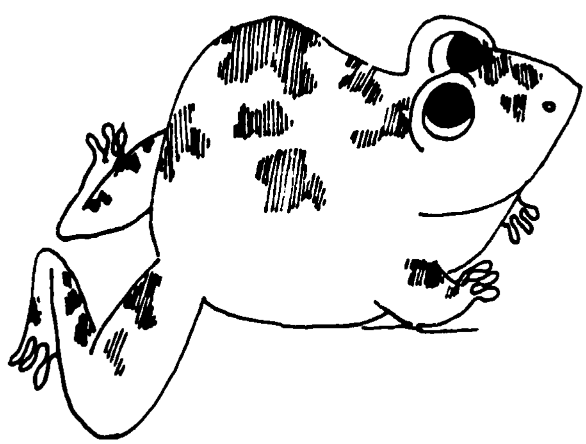
Human Poisoning from Native and Cultivated Plants by James W. Hardin and Jay M. Arena is an excellent reference on poisonous plants. The 194-page book contains photographs, black/white and color, and illustrations. Scientific and common names are given along with description, occurrence, poisoning, and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

Science Fairs

Science fairs offer an excellent opportunity for students to engage in scientific research and meaningful learning experiences. Now that North Carolina educators have reestablished a state science fair, the number of students who participate will continue to grow. The sponsors of science fairs at the local, regional and state levels need to be aware of potential safety problems. The following recommendations should be considered when planning science fairs:

- All projects should be carefully screened for potential hazards before students begin project work.

- Projects should not involve the use of hazardous or toxic substances.
- When live vertebrate animals are to be used, activities should be carefully screened for safety and humane aspects.
- Wild, diseased, or dangerous organisms should not be used with projects.
- Projects with live vertebrate animals should not involve procedures that could be construed inhumane.
- Equipment or energy sources that are faulty or dangerous should not be used.
- Projects should not involve plant material that is dangerous.



<u>*Animals in the Instructional Program*</u>

The use of live animals in the instructional program, including science fairs and projects, 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 continues to be a very 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, the National Society for Medical Research, and the American Psychological Association 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 ex uded from this ruling and are eligible."

At the 27th International Science and Engineering Fair, Dr. M. W. Fox of the Humane Society of the United States, 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]

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 nonlaboratory 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.

[Guidelines for Animal Use]

The guidelines below from the National Science Teachers Association and the National Association of Biology Teachers are duplicated, with permission, for your consideration.

Position Statement of the National Science Teachers Association, Washington, DC

CODE OF PRACTICE ON ANIMALS IN SCHOOLS

This code of practice is recommended by the National Science Teachers Association for use throughout the United States by elementary, middle/junior high, and secondary-school teachers and students. It applies to educational projects involving live organisms conducted in schools, or in school-related activities, such as science clubs, fairs, competitions, and junior academies.

The purpose of these guidelines is to enrich education by encouraging students to observe living organisms and to learn proper respect for life. Study of living organisms is essential for an understanding of living processes. This study, however, must go hand-in-hand with observation of humane principles of animal care and treatment which are described below. These principles apply to vertebrates.

A. A teacher must have a sure understanding *of* and *strong commitment to responsible care of living creatures* before making any decision to use live organisms for educational purposes. Preparation should include acquisition of knowledge on care appropriate for that species, as well as housing and other equipment needs and food, and planning for care of the living creatures after completion of study.

B. Teachers should try to assure that live organisms entering a classroom are *healthy and free from transmissible diseases* or other problems that may endanger human health. Not all species are suitable. Wild animals, for instance, are frequent carriers of parasites and disease and generally are not appropriate.

C. Of primary importance is *maintenance of good animal health and provision of optimal care* based on an understanding of the life habits of each species. Animal quarters shall be spacious and avoid overcrowding, and be sanitary. Handling shall be gentle. Food shall be palatable to the species and of sufficient quantity and balance to maintain a good standard of nutrition at all times. No animal shall be allowed less than the optimum maintenance level of nutrition. Clean drinking water shall always be available. Adequate provision shall be made for the animal's care at all times, including weekends and vacation periods.

D. *Experimental procedures conducted on vertebrate animals shall include only those which do not involve pain* or discomfort to the animal (see details below under "Experimental Studies").

E. All aspects of animal care and treatment shall be *supervised by a qualified individual* who will ensure that proper standards are maintained.

F. Supervisors and students should be familiar with appropriate *literature on care and handling* of living organisms. Practical training in learning these techniques is encouraged.

G. Adequate plans should be made to *control possible unwanted breeding* of the species during the project period.

H. Appropriate plans should be made for *what will happen to the living creatures at the conclusion of the study*. Sometimes it may be possible to find a comfortable home for an animal with a responsible person.

I. As a general rule, *laboratory-bred or non-native species should not be released into the wild*. For instance, in some climates, *Xenopus* frogs, or gerbils, if released, can disturb the normal ecosystem or become pests.

J. On rare occasion it may be appropriate to sacrifice an animal for educational purposes. This shall be done in an approved humane (rapid and painless) manner by a person experienced in these techniques and it should *not* be done in the presence of immature or young students who may be upset by witnessing such a procedure. Maximum efforts should be made to study many biological principles and *utilize as many body tissues as possible from a single animal.*

K. The procurement, care, and use of animals must comply with existing local, state and federal regulations.

"Experimental Studies"

1. In biological procedures involving living organisms, *species of plants, bacteria, fungi, protozoa, worms, snails, insects and other invertebrate animals should be used wherever possible.* Their wide variety, ready availability, and simplicity of maintenance and subsequent disposal make them especially suitable for student work.

2. *Some sample plant, protozoan, and/or invertebrate projects* include: field studies and natural history (life cycle, incidence in nature, social structure, etc.); germination; genetics; reproduction, effect of light, temperature, other environmental factors, and hormones on growth and development; feeding behavior; nutritional requirements; circulation of nutrients to tissues; metabolism; water balance; excretion; movement; activity cycles and biological clocks; responses to gravity and light; perception to touch, humidity and vibration; learning and maze running; habitation; communication; pheromones; observations of food chains and interdependence of one species on another.

3. *No experimental procedures shall be attempted on mammals, birds, reptiles, amphibians, or fish that cause the animal pain* or distinct discomfort or that interfere with its health. As a rule of thumb, a student shall only undertake those procedures on vertebrate animals that could be done on humans without pain or hazard to health.

4. Students shall *not perform surgery* on vertebrate animals.

5. *Examples of non-painful, non-hazardous projects on some vertebrate species* (including, in some instances, human beings) include some already mentioned under item (2) and also: group behavior; normal growth and development; properties of hair, pulse rate and blood pressure; various normal animal behaviors such as grooming, and wall-seeking; reaction to novelty or alarm; nervous reflexes and conditioned responses; special senses (touch, hearing, taste, smell, and proprioceptive responses); and respiration. None of these projects requires infliction of pain or interference with normal health.

6. *Experimental procedures shall not involve* use of microorganisms which can cause diseases in man or animals, ionizing radiation, cancer-producing agents, or administration of alcohol or other harmful drugs or chemicals known to produce toxic or painful reactions or capable of producing birth defects.

7. *Behavioral studies should use only reward* (such as providing food) and not punishment (such as electric shock) in training programs. Food, when used as reward, shall not be withdrawn for periods longer than 12 hours.

8. *Diets deficient in essential nutrients are prohibited.*

9. *If bird embryos* are subjected to invasive or potentially damaging experimental manipulations, the embryo must be destroyed humanely two days prior to hatching. If normal embryos are to be hatched, satisfactory humane provisions must be made for the care of the young birds.

10. On rare occasion it may be appropriate to *pith a live frog* for an educational demonstration. Correct procedure is rapid and virtually painless, and the animal should never recover consciousness. However, if done incorrectly, this procedure can cause pain. The technique should be learned initially using dead animals. Pithing live animals should only be undertaken by a person knowledgeable in the technique.

11. *Protocols* of extracurricular projects involving animals *should be reviewed in advance* of the start of work by a qualified adult supervisor. Preferably, extracurricular projects should be conducted in a suitable area in the school.

12. High school students may wish to take assistant positions with professional scientists working in established, USDA-registered research institutions.

NABT GUIDELINES FOR THE USE OF LIVE ANIMALS AT THE PRE-UNIVERSITY LEVEL

Living things are the subject of biology and their direct study is an appropriate and necessary part of biology teaching. Textbook instruction alone cannot provide students with a basic understanding of life and life processes. We further recognize the importance of research to understanding life processes and providing information on health, disease, medical care, and agriculture.

The abuse of any living organism for experimentation or any other purpose is intolerable in any segment of society. Because biology deals specifically with living things, professional biological educators must be especially cognizant of their responsibility to prevent inhumane treatment of living organisms in the name of science and research. This responsibility should extend beyond the confines of the teacher's classroom to the rest of the school and the community.

The National Association of Biology Teachers, in speaking to the dilemma of providing a sound biological education at the secondary level, while addressing the problem of humane experimentation, presents the following guidelines on the use of live animals at the pre-university level.

A. Biological experimentation should lead to and be consistent with a respect for life and all living things. "Humane treatment and care of animals should be an integral part of any lesson which includes living animals."

B. All aspects of exercises and/or experiments dealing with living things must be within the comprehension and capabilities of the students involved. It is recognized that these parameters are necessarily vague, but it is expected that competent teachers of biology can recognize these limitations.

C. Lower orders of life such as bacteria, fungi, protozoans, and insects can reveal much basic biological information and are preferable as subjects for invasive studies wherever and whenever possible.

D. Vertebrate animals can be used as experimental organisms in the following situations:

   1. Observations of normal living patterns of wild animals in the free living state or in zoological parks, gardens, or aquaria.

   2. Observations of normal living patterns of pets, fish, or domestic animals.

   3. Observations of biological phenomena, i.e., inducing ovulation in frogs through hormone injections, that do not cause discomfort or adverse effects to the animals.

E. Animals should be properly cared for as described in the following guidelines:

1. Appropriate quarters for the animals being used should be provided in a place free from undue stresses. If housed in the classroom itself, animals should not be constantly subjected to disturbances that might be caused by students in the classroom or other upsetting activities.

2. All animals used in teaching or research programs must receive proper care. Quarters should provide for sanitation, protection from the elements, and have sufficient space for normal behavioral and postural requirements of the species. Quarters shall be easily cleaned, ventilated, and lighted. Proper temperature regulation shall be provided.

3. Proper food and clean drinking water for those animals requiring water shall be available at all times in suitable containers.

4. Animals' care shall be supervised by a science teacher experienced in proper animal care.

5. If euthanasia is necessary, animals shall be sacrificed in an approved, humane manner by an adult experienced in the use of such procedures. Laboratory animals should not be released in the environment if they were not originally a part of the native fauna. The introduction of non-native species which may become feral must be avoided.

6. The procurement and use of wild or domestic animals must comply with existing local, state, or federal rules regarding same.

F. Animal studies should be carried out under the provisions of the following guidelines:

1. All animal studies should be carried out under the *direct* supervision of a competent science teacher. It is the responsibility of that teacher to ensure that the student has the necessary comprehension for the study being done.

2. Students should not be allowed to take animals home to carry out experimental studies. These studies should be done in a suitable area in the school.

3. Students doing projects with vertebrate animals should adhere to the following:

a. No experimental procedures should be attempted that would subject animals to pain or distinct discomfort

b. Students should not perform surgery on living vertebrate animals.

4. Experimental procedures should not involve the use of microorganisms pathogenic to humans or other animals, ionizing radiation, carcinogens, drugs or chemicals at toxic levels, drugs known to produce adverse or teratogenic effects, pain-causing drugs, alcohol in any form, electric shock, exercise until exhaustion, or other distressing stimuli.

5. Behavioral studies should use only positive reinforcement in training studies.

6. Egg embryos subjected to experimental manipulation must be destroyed humanely at least two days prior to hatching. Normal egg embryos allowed to hatch must be treated humanely within these guidelines.

7. The administration of anesthetics should be carried out by a qualified science teacher competent in such procedures. (The legal ramifications of student use of anesthetics are complex and such use should be avoided.)

G. The use of living animals for science fair projects and displays shall be in accordance with these guidelines. In addition, no living vertebrate animals shall be used in displays for science fair exhibits.

H. In those cases where the research value of a specific project is obvious by its potential contribution to science, but its execution would be otherwise prohibited by the guidelines governing the selection of an appropriate experimental animal or procedure, exceptions can be obtained if:

1. the project is approved by and carried out under the *direct* supervision of a qualified research scientist in the field; *and*

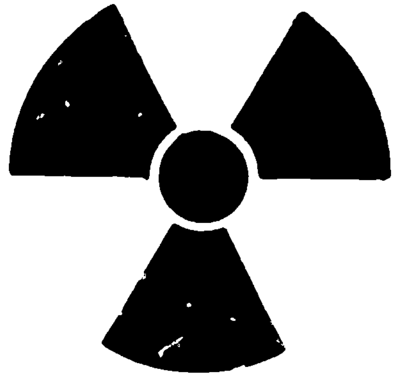
2. the project is carried out in an appropriate research facility designed for such projects; *and*

3. the project is carried out with the utmost regard for the humane care and treatment of the animals involved in the project.

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, NW, Washington, DC 20005.

"How to Care for Living Things in the Classroom," Grace K. Pratt, National Science Teachers Association, 1742 Connecticut Avenue, NW, 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.



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. Department of Energy 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 handled or stored.

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 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 U. S. Department of Energy, Office of Public Affairs, Washington, DC 20545, for disposal or use of radioisotopes of radiation levels above the microcurie range. North Carolina has laws regulating radioactive substances.[2] For information contact the Radiation Protection Branch, North Carolina Department of Human Resources, P.O. Box 12200, Raleigh, NC 27605, (919) 733-4283.

[X-ray Machines]

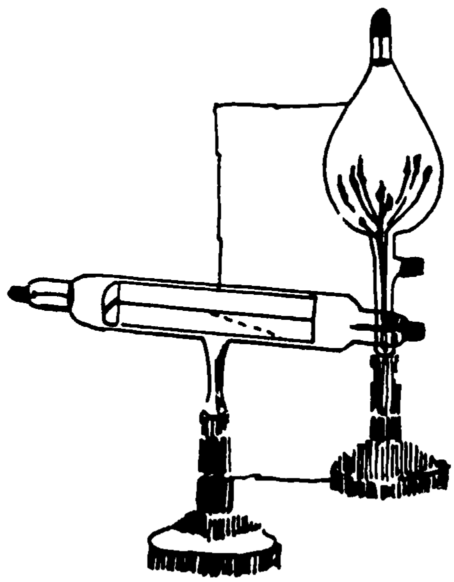
According to North Carolina law,[2] all X-ray machines must be registered with the State of North Carolina. No X-ray machine should be possessed or used by a school unless it has been registered with the Radiation Protection Branch, N. C. Department of Human Resources, P.O. Box 12200, Raleigh, NC 27605, (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

[2]The North Carolina Radiation Protection Act G.S.104E allows adoption of Rules under the North Carolina Regulations for Protection against Radiation.

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 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 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.

[Mercury Vapor Lamps]

The high intensity discharge tubes commonly used as light sources in many schools can present a radiation hazard if the outer protective envelope is broken.

[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, (Report No. 32), is a recommended publication for teachers using radiation sources in the science curriculum. It is available from the National Council on Radiation Protection, 7910 Woodmont Avenue, Suite 1016, Bethesda, MD 20814.

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% of lasers used in high schools and 79% 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.[3] The 7-milliwatt figure represents a calculated power that produces retinal burns in 50% 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 one second produced a retinal burn in one monkey.
- Production of visible retinal burns in Rhesus monkeys exposed to 2.0 milliwatts for one second has been independently reported.[4]

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

[4]Frisch, "Retinal Injury Thresholds from Argon Laser Radiations," Department of Army, Frankford Arsenal, Memorandum Report 70-21-1, June 1970.

- Human injury from a Helium-Neon laser has been reported.[5] 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.[6] 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[7] 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.

- 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.

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

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

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

- 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 openable 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 accidentally 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, 1980, American National Standards Institute, 1430 Broadway, New York, NY 10018.

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

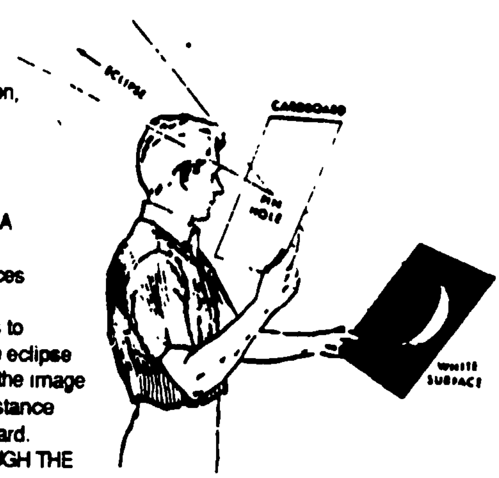
SOLAR ECLIPSE MARCH 7, 1970

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 exlipse 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:

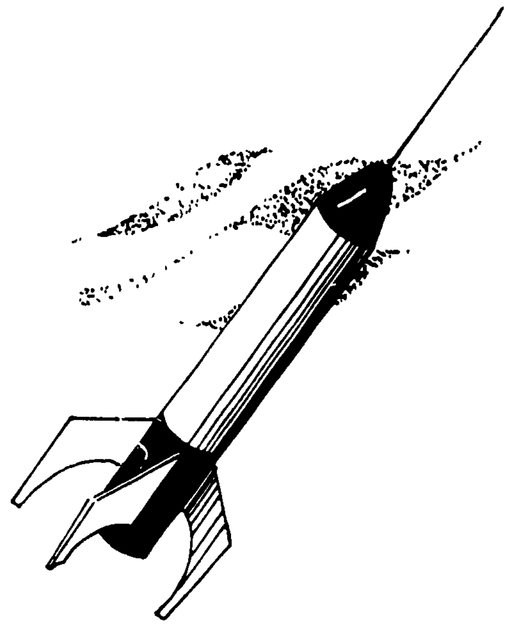
The danger of the retinal burn comes from the invisible infrared rays which penetrate light filters and instantaneously damage eyes. The retina is not sensitive to pain, henceforth the victim might not immediately be aware of eye damage. Retinal burns are incurable and destroy the field of fine vision.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

Prepared and distributed by the State Department of Public Instruction, Raleigh, North Carolina 27602

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, breakable plastic, paper, containing no substantial metal parts. The total mass of the rocket should not exceed 453 grams, including the propellant.[8]

[8]Rockets that exceed this mass come under different Federal Aviation regulations. Users should contact the nearest air traffic control facility for necessary clearance information. (Charlotte area--phone (704) 392-3214; Raleigh area--phone (919) 755-4240)

- Engines--Should be solid, slow burning 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.

- The rocket should be operated in a manner that does not create a hazard to persons, property, or other aircraft.

- 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.[9] This publication also provides safety codes and other valuable information. It is free upon request.

- Launching system--Should be remotely controlled and electrically operated by a switch that will return to off when released. A minimum distance of five meters 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 or combustible materials. The smallest dimension of the ground area should be no less than 1/4 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 guide entitled Code for Unmanned Rockets, (#1122) is available from the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

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[9] Daniel F. Saltrick, Alfred M. Kubota, and Robert L. Cannon, Aerospace Education and Model Rocketry. 2nd edition (Penrose, CO 81240: Estes Industries, 1975).

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 the 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 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."

Recently, in North Carolina, two sixth graders received serious burns when left to fill alcohol lamps.

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 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. (Metal-type lamps are preferred.)

- 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.

- A pinch of salt (sodium chloride) in an alcohol lamp will give the flame better visibility, hence a safer flame.

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North Carolina Publications

North Carolina Occupational Safety and Health Standards for General Industry. North Carolina Department of Labor, Raleigh, NC 27601, 1974.

North Carolina Public Schools: Fire Safety. State Department of Public Instruction, Raleigh 27603-1712, 1980.

Public School Laws of North Carolina. State Board of Education, Raleigh, 27603-1712, 1988.

Safety in North Carolina Public Schools and Institutions of the Community College System. State Board of Education, Division of Plant Operation, Raleigh, 27603-1712, 1974.

Other Sources

American National Standard for the Safe Use of Lasers. American National Standards Institute, New York, NY, 1973.

Data sheets by National Safety Council, 444 North Michigan Avenue, Chicago, IL:

Animals in the Classroom (#429.04-37)
Chemicals (#429.04-14)
Laboratory Glassware (#429.04-23)
Poisonous Plants (#429.04-08)
Poisonous Snakes (#429.04-35)
Safety in the Chemistry Laboratory (#429.04-59)

Guiding Principles in the Use of Animals by Secondary School Students and Science Club Members. National Society for Medical Research, Washington, DC, 1969.

Is Your Laboratory A Safe Place to Work? Lab Safety Supply Company, P. O. Box 1368, Janesville, WI 53547, 1977.

Rules and Regulations for the Westinghouse Science Scholarships and Awards. Science Service, 1719 N Street, NW, Washington, DC 20036, 1976.

Dissertations

Barnett, Harvey B. "An Analysis of Court Decisions Pertaining to Tort Liability for Student Injuries Sustained in Science Activities in Public School Systems Throughout the United States." Doctoral Dissertation, Virginia Polytechnic Institute and State University, 1977.

Brennan, John Wesley. "An Investigation of Factors Related to Safety in the High School Science Program." EdD Dissertation, University of Denver, 197C (microfilm ED 085 179)

Singh, Karan. "Toxic Effects of Chemical Substances in High School Chemistry Laboratories." An unpublished doctoral dissertation, University of Cincinnati, 1981.

Recommended References and Audiovisuals

The following references are recommended as basic for any senior high school:

Guide for Safety in the Chemical Laboratory. Manufacturing Chemists Association. Published by Van Nostrand Reinhold Company, New York, NY, 1972.

This publication contains a wealth of lab safety information. It provides specific disposal information for over 1,000 chemicals. A table of technical data is also provided.

Manual of Hazardous Chemical Reactions. NAPA #491M. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

Manual of Safety and Health Hazards in the School Science Laboratory. National Institute for Occupational Safety and Health, Cincinnati, OH 45226, 1980. The cost is $6.00 and includes postage.

This publication surveys major science texts and lab manuals for health and safety hazards. Experiments in biology, chemistry, earth science, and physics are rated and recommendations for safe alternatives are suggested. This publication is available only through the Council of State Science Supervisors, Attention: Mr. Frank Kizer, Route 2, Box 637, Lancaster, VA 22503.

Merck Index (9th Edition). Merck and Company, Inc., Rahway, NJ.

An excellent reference for technical data on over 10,000 chemicals. Information is included on drugs, chemicals, pesticides, and biologically-active substances.

Safety in the School Science Laboratory. National Institute for Occupational Safety and Health, Cincinnati, OH 45226, 1979.

This publication is the text for a 16-hour safety in-service program for secondary science teachers. It is only available through State Departments of Education. In North Carolina, the Division of Science provides free copies to all who attend the Safety Leadership Workshops.

Audiovisuals

16mm films:

"Eye and Face Protection in the Chemical Laboratory," color, 13 1/2 minutes.

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

"School Lab Safety," (Biological and Physical), color, 20 minutes.

"Flammable Liquids," color, 16 minutes.

Available from Handel Film Corporation, 8730 Sunset Boulevard, West Hollywood, CA 90069.