# IS YOUR SCIENCE LABORATORY SAFE?

## BY CLEON WHITE

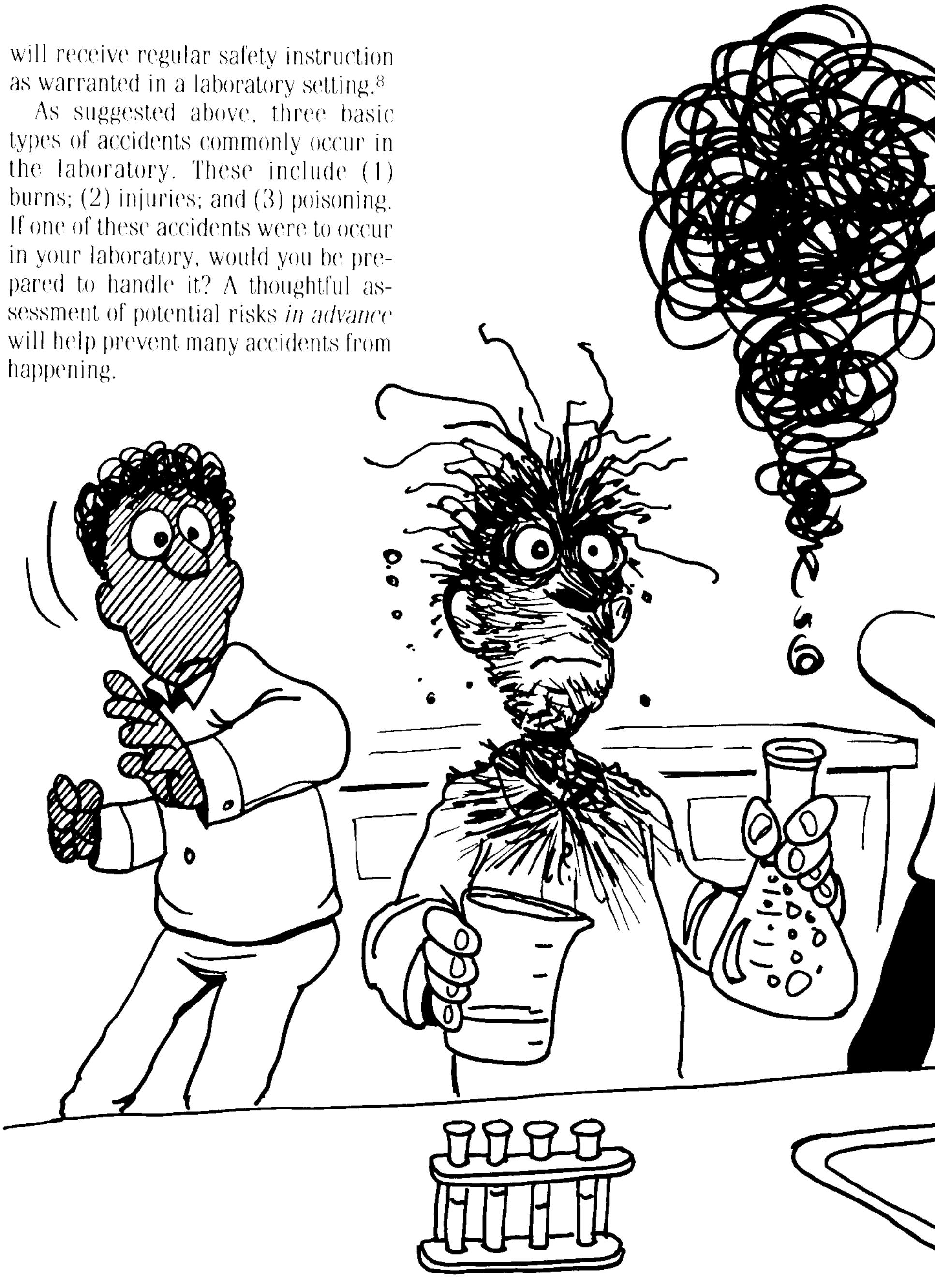
Even though there is reason to acclaim the progress in methods, equipment, and construction of the science laboratory since the days of the alchemists, some of the same hazards still exist in modern laboratories. Despite these hazards, however, learning about science requires doing. The ancient Chinese proverb states it well: "I hear, and I forget; I see, and I remember; I do, and I understand."[1]

While hands-on experience is important, the instructor must always be alert to problems that might occur in the lab and give careful direction before an accident occurs rather than reprimand after the fact!

"Fully 80-85% of all accidents result from unsafe personal acts."[2] During the 1977-1978 school year about 2,900 of the 22,000 reported school accidents were science-related.[3] The most common accidents involve cuts, burns, glass, and chemicals.[4] This frequency is supported by a 1983 survey conducted in New Jersey.[5] A survey by Young indicated approximately one major accident per 40 students per year.[6] Barrett states that the most frequently cited grounds for legal action in the cases he reviewed was negligence in instruction and supervision.[7]

The science instructor must continually stress safety guidelines. It is insufficient to simply post such guidelines, read them to the class, or distribute them. The courts expect that students will receive regular safety instruction as warranted in a laboratory setting.[8]

As suggested above, three basic types of accidents commonly occur in the laboratory. These include (1) burns; (2) injuries; and (3) poisoning. If one of these accidents were to occur in your laboratory, would you be prepared to handle it? A thoughtful assessment of potential risks *in advance* will help prevent many accidents from happening.



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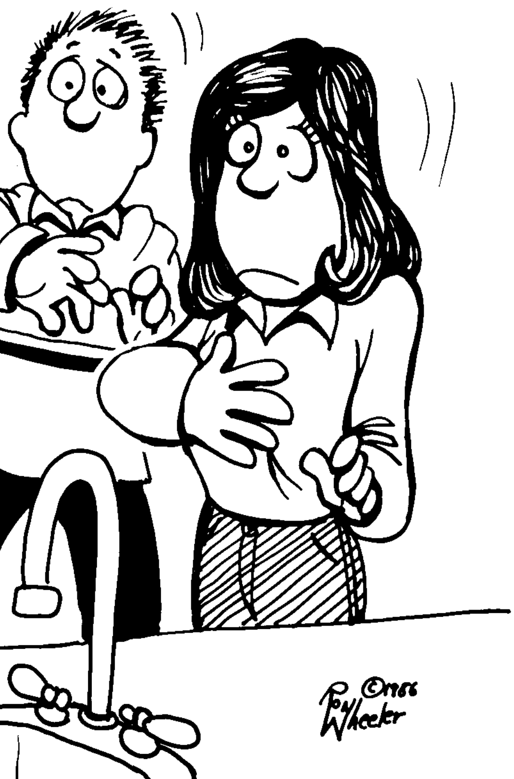
A well stocked first-aid kit needs to have first priority in your laboratory. It simply will not do to have the kit in some secluded place in the office or across campus. In addition to the usual complement of bandages, tourniquets, and ointments, science lab first-aid kits need to include the following: aromatic spirits of ammonia, drinking cups, forceps, first-aid card, scissors, sterile boric acid, emergency eyewash, eye dressing kit, and an ice-pack compress. A shower and fire blanket should be nearby.

The latest edition of *Standard First Aid and Personal Safety* should be kept with the kit. Every science instructor must be knowledgeable about good first-aid technique as it applies to school laboratories. If an accident occurs, above all, avoid panic. Students can be called upon to help if they are willing to listen to the careful guidance of an experienced adult.

LeRoy Rickard, manager of claim services for the church's Risk Management Services, indicates that he knows of no reported laboratory accidents in the SDA educational system since 1979. In that year a chemistry student at Andrews University became the victim of a serious acid spill. Rickard said that as far as he knows, the secondary school laboratories have had no reported accidents. Presently, General Conference Risk Management Services provides a first-line liability of one million dollars for participating schools in the church's educational system.[9]



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Students often have a limited idea or incorrect concept of the tools used in a laboratory setting. Therefore, at the beginning of the school year the teacher should conduct a tour of the lab (in groups of three or four) to demonstrate the location of all the important items and answer student questions about materials and procedures. This will help the instructor determine potential hazards when the laboratory is in session.

## Teachers Need Safety Training Too

Many teachers have had little or no safety training. Until recently, laboratory manuals and textbooks have been vague about specific problems that could occur. This pattern is changing. Many science programs now offer excellent guidance about potential hazards.

A study conducted in 1985 indicated a real need to teach safety in laboratory classes. Before conducting the experimental part of the study, researchers observed students using the following unsafe practices in biology and chemistry laboratory settings:

1. Leaving the laboratory working area without washing their hands.
2. Working in a cluttered area.
3. Working without correct protective eyewear.
4. Horseplay involving poking, bumping, and dodging.
5. Handling broken glass with bare hands.
6. Touching face and eyes before washing hands.
7. Eating candy.
8. Handling an electrical apparatus with wet hands.

When researchers demonstrated safe procedures, both students and instructors improved their techniques and safety skills.[10]

A lab safety workshop was held in the eastern United States recently with very positive results. Issues included: (1) storing chemical bottles that extend beyond the shelf; (2) solving the problem of chemical shelves with lips; (3) handling bottles with labels but lacking any dates; (4) dealing with chemical spills of unknown origin; (5) disposing of unmarked containers; (6) storing chemicals alphabetically; and (7) choosing correct eyewear.[11]

In early 1987 a new edition of *Safety in the Secondary Science Classroom* will be published by the National Science Association. This reference work should have a place in every science teacher's library.[12]

The science teacher should thoroughly research the potential hazards prior to any chemical demonstration. An excellent source for such information can be found in *The Handbook of Reactive Chemical Hazards*.[13]

## Right-to-Know Laws

Currently there is much confusion regarding the newly passed "right-to-know" rulings affecting chemicals available to the public.[14] These laws will affect school laboratories in several ways. Schools that purchase chemicals should now receive material data sheets from manufacturers. The laws may also require schools to inform employees of the hazards of chemicals in the workplace. This would probably include student assistants in labs. If schools manufacture chemicals, they will fall under the same guidelines as other producers of hazardous materials. The reader should check with local state officials to determine the laws in his or her jurisdiction.

## Disposing of Hazardous Chemicals

New rules issued by the U.S. Environmental Protection Agency now require every institution that generates more than 100 kilograms of hazardous waste per month (half of a 55-gallon

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teacher gains insight into the students' prior knowledge about the topic and can assess the class's readiness for the new information. As discussion progresses, student leaders develop and group dynamics increases. Students become more interested in the topic as they rummage through their stored knowledge for a fact suitable for public presentation.

### Current Events—Ready-made Motivators

Teachable moments can constitute either a threat or an opportunity to a teacher, depending on training and preparedness. The perceptive teacher can tell whether a student is asking a question just to kill time or because he or she really wants to learn more about the topic.

Listening to television and radio news, and reading the daily newspaper can provide ideas for discussion in class. Sometimes it is just coincidental that you are studying viruses when HTLV-III is identified, or just describing nuclear reactions when Chernobyl blows up.

At other times, by being flexible and preparing some materials in advance, you can insert a unit in a different sequence than you had planned. By so doing, you can highlight the connection between science and current events.

Articles in newspapers and popular magazines can also be used to get students interested in the literature of science. The MacNeil/Lehrer NewsHour could be recommended viewing on the evening of an announcement of a scientific breakthrough. *Discover* or wildlife magazines could be required reading on a health or environmental issue. Newspapers can offer starter details for a composition or debate. *Time* or *Newsweek* can be useful in highlighting trends or new discoveries in science through their regular columns on the subject. Students can be encouraged to spend part of their allowance on a magazine to share with the class. A habit of reading or scanning publications, if begun at the high-school level, will continue throughout life.

The student with a lively curiosity about the world around him will never be bored. The teacher sets the tone by example and assignment. If you keep up-to-date through a wide variety of reading materials, your students will see that this is an interesting and productive thing to do.

### Try It and See

Science presents many puzzling things to wonder about and to try to figure out. In chemistry class, during a lab or demonstration, students often ask, "What would happen if I mixed these together?" If you know the consequences would be disastrous, describe the problems that would result. But in most cases you could safely say, "Let's try it and see!"

The results could offer a springboard for discussion, for introducing a new topic, or even for demonstrating that, as yet, some things in the field of science haven't been explained. This approach encourages experimentation and fosters a spirit of curiosity. Science often happens in ways you may not have anticipated, ways that were not in your lesson plan for the day.

### Student Sees—Student Does

In all your classroom presentations—audio-visuals, handouts, lectures, displays, demonstrations, labs—the quality of the work students are expected to do is modeled by the teacher. Excellence begets excellence.

However, in everyone's work there are bound to be tiny errors or projects that don't turn out so well. Such occurrences show students how to deal with failure, teaching them that mistakes can lead to growth. By seeing their teacher handle problems gracefully, they learn not to be afraid to try. They come to understand that people grow and improve through experience.

"HE JUST GOT A PRICE QUOTE ON LIABILITY INSURANCE FOR THE SCHOOL. HELP ME PRY THE PHONE OUT OF HIS HAND!"

### Adventist Science Teaching—The Difference

The theory of evolution permeates text and ancillary publications as well as TV and print media. Teachers must be constantly alert to the need to adapt these materials for classroom use. There are endless subtle references to "millions of years," and "earlier life forms." These must be carefully noted and corrected to avoid leading students astray.

Since repetition promotes learning, the teacher should frequently repeat the fact that the complexity of chemical/physical/biological principles gives clear and convincing evidence of the creativity of God, the Designer of the universe. Nearly every science topic offers ample opportunity to mention that the processes being studied are not the result of random happenings. For example, in physiology, we can celebrate God's creation—the magnificence of the human body and its function.

### Conclusion

Teacher enthusiasm and effective presentations can help make the science classroom an interesting place. Truly creative science teaching can happen at every level in our schools. □

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steel drum) to follow more stringent federal regulations for storing and getting rid of such chemicals. Experts say nearly all colleges produce at least that much each month. Chemicals included in these regulations include flammable solvents from the chemistry lab, pesticides from the grounds crew, and oil paints from art classes.

Schools that produce at least 100 kilograms of hazardous materials per month will now have to register with state or federal officials, keep on file records of the amounts and kinds of hazardous waste produced, who transported it for them, and where it was finally disposed.

Institutions that produce larger amounts of toxic materials already had to register with state or federal officials, but this is the first time smaller schools have come under federal guidelines. The average small college can expect to spend about $3,000 to $5,000 a year to get rid of its wastes under the new rules, according to hazardous materials management officials.[15]

## Long-Range Hazards

Long-range hazards are probably the greatest source of concern in science labs. It is very difficult to know whether exposure to certain chemicals will affect the human body at a later time. Teachers have a responsibility to guard their own bodies and those of their students against harm, since they are the temple of God.

An excellent definition of a toxic chemical (poison) appears in *Dorland's Illustrated Medical Dictionary*. It is "any chemical which when ingested, inhaled, or absorbed, or when applied to, injected into or developed within the body, in relatively small amounts, by its chemical action may cause damage to structure or disturbance of function."[16]

The American Conference of Governmental Industrial Hygienists publishes a booklet every year listing the toxicity levels of a new group of chemicals.[17]

According to the *Laboregister*, a chemical can be judged to be hazardous (at least in industrial terminology) if it is found on one of the following lists: (1) OSHA's Regulated Substances; (2) American Conference of Governmental Industrial Hygienists Threshold Limit Values; (3) National Toxicology Program Annual Report on Carcinogens; or (4) International Agency for Research on Cancer Monographs.[18]

## Arranging Chemicals for Safety

Many chemicals become toxic or explosive when combined with other compounds. To avoid dangerous interactions between chemicals, avoid arranging chemicals in alphabetical order. It is far better to use a design similar to the one suggested by the Flinn Scientific Inc. Catalog/Reference Manual.[19]

When storing chemicals, the following facts need to be included on the label:

1. Identity of product or hazard component(s)
2. Signal word
3. Statement of Hazard for each of the hazards
4. Precautionary measure
5. Instructions in case of contact or exposure
6. Antidotes
7. Notes to physicians
8. Instructions in case of fire or spill or leak
9. Instructions for container handling and storage.

There are three levels of chemical hazard—DANGER represents the highest degree of potential hazard; WARNING, intermediate degree; and CAUTION, the lowest degree. In the event that a certain chemical has multiple hazards, the signal word denotes the degree of greatest hazard. For highly toxic chemicals, the word POISON and a skull and crossbones are used.[20]

*The most frequently cited grounds for legal action . . . was negligence in instruction and supervision.*

What should you do with lab materials that are not labeled? Many tests will need to be run to find out the substance's compatibility with polar and nonpolar solvents, and other compounds.[21]

## Conclusion

SDA teachers have a right to be proud of their low incidence of reported accidents in school science laboratories. However, we must not rest on our laurels. New materials and laws are continually being produced to make the laboratory a safer place to work and learn. Reading current literature, reflecting on your own particular classroom design, and studying the behavior of your students will play a large role in the success—and safety—of school science programs.

We must continue to watch for side effects of chemicals that were not previously considered dangerous and heed the warnings on labels of known hazardous compounds. We must also teach our students good safety habits. If we help them develop a respect for hazardous materials, this attitude will benefit them throughout their lives. □

### FOOTNOTES

1 Quoted in Ken Macrorie, *20 Teachers* (New York: Oxford University Press, 1984), p. 68.

2 JoAnne M. Dombrowski and Ray R. Hagelberg, "The Effects of a Safety Unit on Student Knowledge and Behavior," *Science Education*, 69:4 (July 1985), p. 527.

3 National Safety Council, *Accident Facts*, vol. 60 (1981 ed.), pp. 90, 91.

4 H. B. Barrett, "An Analysis of Court Decisions Pertaining to Tort Liability for Student Injuries Sustained in Science Activities in Public Systems Throughout the United States." An unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, 1977; J. A. Gerlovich and G. E. Downs, *Better Science Through Safety* (Ames, Iowa: Iowa State University Press, 1981).

5 J. G. Krajkovich, "A Survey of Accidents in the Secondary School Science Laboratory, New Jersey Science Supervisors Association," May 1983, 26 pp. Eric Doc. 229 280. Available from: David Sousa, West Orange Board of Education, 22 Municipal Plaza, West Orange, NJ 07052 ($3.50).

6 John R. Young, "A Second Survey of Safety in Illinois High School Laboratories," *Journal of Chemical Education*, 49:1 (January 1972), p. 55.

7 Barrett.

8 Robert A. Dean, Melanie Messer Dean, and LeMoine L. Motz, "Safety in the Secondary Science Classroom" (Washington, D.C.: National Science Teachers Association, 1978), p. 3.

9 Telephone interview with LeRoy Rickard, Manager of Risk Management Services, General Conference of Seventh-day Adventists, Washington, D.C., July 1986.

10 Dombrowski and Hagelberg.

11 Gary E. Dunkleberger, "Safety in the Classroom: A Model for Training Science Teachers," *Journal of Chemical Education*, 62:1 (January 1985), p. 73.

12 Copies may be purchased by calling (202) 328-5800 (Special Publications Dept.) or by writing to the National Science Teachers Association, 1742 Connecticut Ave. NW, Washington, DC 20009. Price, $9.00.

13 L. Bretherick, *The Handbook of Reactive Chemical Hazards* (Woburn, Mass.: Butterworth, 1979).

14 The Federal Occupational Safety and Health Administration (OSHA) on November 25, 1985, began to require chemical manufacturers and importers to assess hazards, develop labels and material safety data sheets, and forward this information to employers in manufacturing establishments. In May 1985 manufacturing employers became responsible for informing and training workers about the hazards in their workplaces, retaining warning labels, and making available material safety data sheets supplied with hazardous products. These regulations preempt less-stringent state laws, but some states have more rigorous requirements. For example, in Michigan, beginning in February 1987, people living in the community, fire fighters, or other local government officials can ask if a particular chemical is being used in a nearby facility. In Michigan, all employers, including nonmanufacturing and public employers, will be required to comply with the right-to-know law. Information can be obtained from local state officials or by writing to the Office of Information, Occupational Health and Safety Administration, Department of Labor, Washington, DC 20530.

15 Colleen Cordes, "Smaller Colleges Are Now Subject to Stiff Hazardous-Waste Rules," *The Chronicle of Higher Education* (September 24, 1986), p. 23. Additional information on hazardous waste disposal may be obtained by calling 1-800-368-5888 (in Virginia, 1-800-468-4561).

16 *Dorland's Illustrated Medical Dictionary*, 26th ed. (Philadelphia: W. B. Saunders Co., 1985), p. 1043.

17 Rudolph Gerlach, "Toxic Chemicals: Understanding TLV's [Threshold Limit Values]," *Journal of Chemical Education*, 63:4 (April 1986), p. A100.

18 "Important Information on the Michigan Right-to-Know Law," *Michigan Department of Labor Laboregister*, 10:5 (May 1986), p. 71.

19 Copies may be obtained by writing to Flinn Scientific, P.O. Box 231, Batavia, IL 60510.

20 Stephen K. Hall, "Labeling in Hazard Communication," *Journal of Chemical Education*, 63:3 (March 1986), p. 225.

21 An excellent scheme for classifying most unlabeled laboratory material is found in the 63:5 (May 1986) *Journal of Chemical Education*, p. A130.