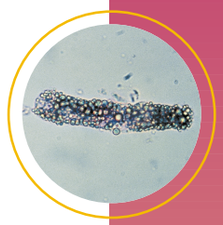
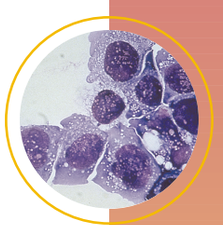
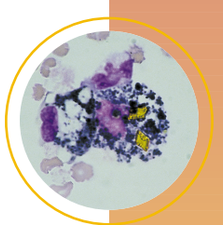
CHAPTER 1







Safety in the Clinical Laboratory

LEARNING OBJECTIVES

Upon completion of this chapter, the reader will be able to:

1. List the components of the chain of infection and the laboratory safety precautions that break the chain.
2. Differentiate among and state the precautions addressed by Universal Precautions, body substance isolation, and Standard Precautions.
3. State the specifics of the Blood-Borne Pathogens Standard.
4. Describe the types of personal protective equipment that laboratory personnel wear, including when, how, and why each article is used.
5. Correctly perform routine handwashing.
6. Describe the acceptable methods for disposing of biological waste in the urinalysis laboratory.
7. Discuss the components and purpose of Chemical Hygiene Plans and Material Safety Data Sheets.
8. State the components of the National Fire Protection Association hazardous material labeling system.
9. Describe precautions that laboratory personnel should take with regard to radioactive and electrical hazards.
10. Explain the RACE actions to be taken when a fire is discovered.
11. Differentiate among class A, B, C, and D fires with regard to material involved and methods of extinguishing each type.
12. Recognize standard hazard warning symbols.

KEY TERMS

biohazardous
body substance isolation
chain of infection
Chemical Hygiene Plan
Material Safety Data Sheet
Occupational Safety and Health Administration
personal protective equipment
radioisotope
Standard Precautions
Universal Precautions

The clinical laboratory contains a variety of safety hazards, many of which are capable of producing serious injury or life-threatening disease. To work safely in this environment, laboratory personnel must learn what hazards exist, the basic safety precautions associated with them, and finally to apply the basic rules of common sense required for everyday safety. As can be seen in Table 1–1, some hazards are unique to the health-care environment, and others are encountered routinely throughout life.

Biological Hazards

The health-care setting provides abundant sources of potentially harmful microorganisms. These microorganisms are frequently present in the specimens received in the clinical laboratory. Understanding how microorganisms are transmitted (***chain of infection***) is essential to preventing infection. The chain of infection requires a continuous link between a source, a method of transmission, and a susceptible host. The source is the location of potentially harmful microorganisms, such as a contaminated clinical specimen or an infected patient. Microorganisms from the source are transmitted to the host. This may occur by direct contact (e.g., the host touches the patient, specimen, or a contaminated object), inhalation of infected material (e.g., **aerosol** droplets from a patient or an uncapped centrifuge tube), ingestion of contaminated food and water, or an animal or insect vector. Once the chain of infection is complete, the infected host then becomes another source able to transmit the microorganisms to others.

In the clinical laboratory, the most direct contact with the source of infection is through contact with patient specimens, although contact with patients and infected objects also occurs. Preventing completion of the chain of infection is a primary objective of biological safety. Figure 1–1 uses the universal symbol for ***biohazardous*** material to demonstrate how following prescribed safety practices can break the chain of infection. Figure 1–1 places particular emphasis on laboratory practices.

Proper handwashing and the wearing of ***personal protective equipment*** (**PPE**) are of major importance in the laboratory. Concern over exposure to blood-borne pathogens, primarily hepatitis B virus (**HBV**) and human immunodeficiency virus (**HIV**), resulted in the drafting of guidelines and regulations by the Centers for Disease Control and Prevention (**CDC**) and the ***Occupational Safety and Health Administration*** (**OSHA**) to prevent exposure. In 1987, the CDC instituted ***Universal Precautions*** (**UP**). Under UP, all patients are considered to be possible carriers of bloodborne pathogens. The guideline recommends wearing gloves when collecting or handling blood and body fluids contaminated with blood, wearing face shields when there is danger of blood splashing on mucous membranes, and disposing of all needles and sharp objects in puncture-resistant containers. The CDC excluded urine and body fluids not visibly contaminated by blood from UP, although many specimens can contain a considerable amount of blood before the blood becomes visible. The modification of UP to ***body substance isolation*** (**BSI**) helped to alleviate this concern. BSI is not limited to bloodborne pathogens and considers all body fluids and moist body substances to be potentially infectious. According to BSI, personnel should wear gloves at all times when encountering moist body substances. A major disadvantage of the BSI guideline is that it does not recommend handwashing following the removal of gloves unless visual contamination is present.

In 1996, the CDC combined the major features of UP and BSI and called the new guidelines ***Standard Precautions***. Although Standard Precautions, as described below, stress patient contact, the principles most certainly can also be applied to patient specimens.[1]

Standard Precautions are as follows:

1. **Handwashing:** Wash hands after touching blood, body fluids, secretions, excretions, and contaminated items, whether or not gloves are worn. Wash hands immediately after gloves are removed, between patient contacts, and when otherwise indicated, to avoid transfer of microorganisms to other patients or environments. Washing hands may be necessary between tasks and procedures on the same patient to prevent cross-contamination of different body sites.
2. **Gloves:** Wear gloves (clean, nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions, and contaminated items. Put on gloves just before touching mucous membranes and nonintact skin. Change gloves between tasks and procedures on the same patient after contact with material that may contain a high concentration of microorganisms. Remove gloves promptly after use,

TABLE 1–1 **Types of Safety Hazards**

Type	Source	Possible Injury
Biological	Infectious agents	Bacterial, fungal, viral, or parasitic infections
Sharp	Needles, lancets, and broken glass	Cuts, punctures, or bloodborne pathogen exposure
Chemical	Preservatives and reagents	Exposure to toxic, carcinogenic, or caustic agents
Radioactive	Equipment and radioisotopes	Radiation exposure
Electrical	Ungrounded or wet equipment and frayed cords	Burns or shock
Fire/explosive	Bunsen burners and organic chemicals	Burns or dismemberment
Physical	Wet floors, heavy boxes, and patients	Falls, sprains, or strains

From Strasinger and DiLorenzo,[5] p 62, with permission.

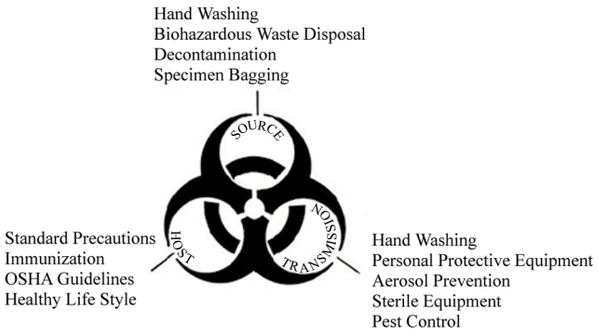


FIGURE 1–1 Chain of infection and safety practices related to the biohazard symbol. (Adapted from Strasinger and DiLorenzo,[5] p 63.)

before touching noncontaminated items and environmental surfaces, and before going to another patient, and wash hands immediately to avoid transfer of microorganisms to other patients or environments.

3. **Mask, eye protection, and face shield:** Wear a mask and eye protection or a face shield to protect mucous membranes of the eyes, nose, and mouth during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.
4. **Gown:** Wear a gown (a clean, nonsterile gown is adequate) to protect skin and to prevent soiling of clothing during procedures and patient-care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, or excretions. Select a gown that is appropriate for the activity and the amount of fluid likely to be encountered. Remove a soiled gown as promptly as possible and wash hands to avoid the transfer of microorganisms to other patients or environments.
5. **Patient-care equipment:** Handle used patient-care equipment soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures, contamination of clothing, and transfer of microorganisms to other patients or environments. Ensure that reusable equipment is not used for the care of another patient until it has been cleaned and reprocessed appropriately. Ensure that single-use items are discarded properly.
6. **Environmental control:** Ensure that the hospital has adequate procedures for the routine care, cleaning, and disinfection of environmental surfaces, beds, bedrails, bedside equipment, and other frequently touched surfaces and ensure that these procedures are being followed.
7. **Linen:** Handle, transport, and process linen soiled with blood, body fluids, secretions, and excretions in a manner that prevents skin and mucous membrane exposures and contamination of clothing and that avoids the transfer of microorganisms to other patients and environments.
8. **Occupational health and bloodborne pathogens:** Take care to prevent injuries when using needles, scalpels, and other sharp instruments or devices; when handling sharp instruments after procedures; when cleaning used instruments; and when disposing of used needles. Never recap used needles, or otherwise manipulate them using both hands, or use any other technique that involves directing the point of a needle toward any part of the body; rather, use either a one-handed "scoop" technique or a mechanical device designed for holding the needle sheath. Do not remove used needles from disposable syringes by hand, and do not bend, break, or otherwise manipulate used needles by hand. Place used disposable syringes and needles, scalpel blades, and other sharp items in appropriate puncture-resistant containers, which are located as close as practical to the area in which the items were used, and place reusable syringes and needles in a puncture-resistance container for transport to the reprocessing area. Use mouthpieces, resuscitation bags, or other ventilation devices as an alternative to mouth-to-mouth resuscitation methods in areas where the need for resuscitation is predictable.
9. **Patient placement:** Place a patient who contaminates the environment or who does not (or cannot be expected to) assist in maintaining appropriate hygiene or environment control in a private room. If a private room is not available, consult with infection control professionals regarding patient placement or other alternatives.

The Occupational Exposure to Blood-Borne Pathogens Standard is a law monitored and enforced by OSHA.[3] Specific requirements of this OSHA standard include the following:

1. Requiring all employees to practice UP/Standard Precautions
2. Providing laboratory coats, gowns, face and respiratory protection, and gloves to employees, and laundry facilities for nondisposable protective clothing
3. Providing sharps disposal containers and prohibiting recapping of needles
4. Prohibiting eating, drinking, and smoking, and applying cosmetics in the work area
5. Labeling all biohazardous material and containers
6. Providing free immunization for HBV
7. Establishing a daily disinfection protocol for work surfaces. The **disinfectant** of choice for bloodborne pathogens is sodium hypochlorite (household bleach diluted 1:10).
8. Providing medical follow-up for employees who have been accidentally exposed to bloodborne pathogens
9. Documenting regular training in safety standards for employees

PERSONAL PROTECTIVE EQUIPMENT

PPE used in the laboratory includes gloves, fluid-resistant gowns, eye and face shields, and Plexiglas countertop shields. Gloves should be worn when in contact with patients, specimens, and laboratory equipment or fixtures.

When specimens are collected, gloves must be changed between every patient. In the laboratory, they are changed whenever they become noticeably contaminated or damaged and are always removed when leaving the work area. Wearing gloves is not a substitute for handwashing, and hands must be washed after gloves are removed. A variety of gloves are available, including sterile and nonsterile, powdered and unpowdered, and latex and nonlatex. Allergy to latex is increasing among health-care workers, and laboratory workers should be alert for any allergy symptoms, such as redness or a rash after removing gloves. Should allergy symptoms occur, use of latex products must be avoided in the future.

Fluid-resistant laboratory coats with wrist cuffs are worn to protect clothing and skin from exposure to patients' body substances. They should always be completely buttoned, and gloves should be pulled over the cuffs. Coats are worn at all times when working with patient specimens and are removed prior to leaving the work area. They are changed when they become visibly soiled. Disposable coats are placed in containers for biohazardous waste and nondisposable coats in designated laundry receptacles.

The mucous membranes of the eyes, nose, and mouth must be protected from specimen splashes and aerosols. A variety of protective equipment is available, including goggles, full-face plastic shields, and Plexiglas countertop

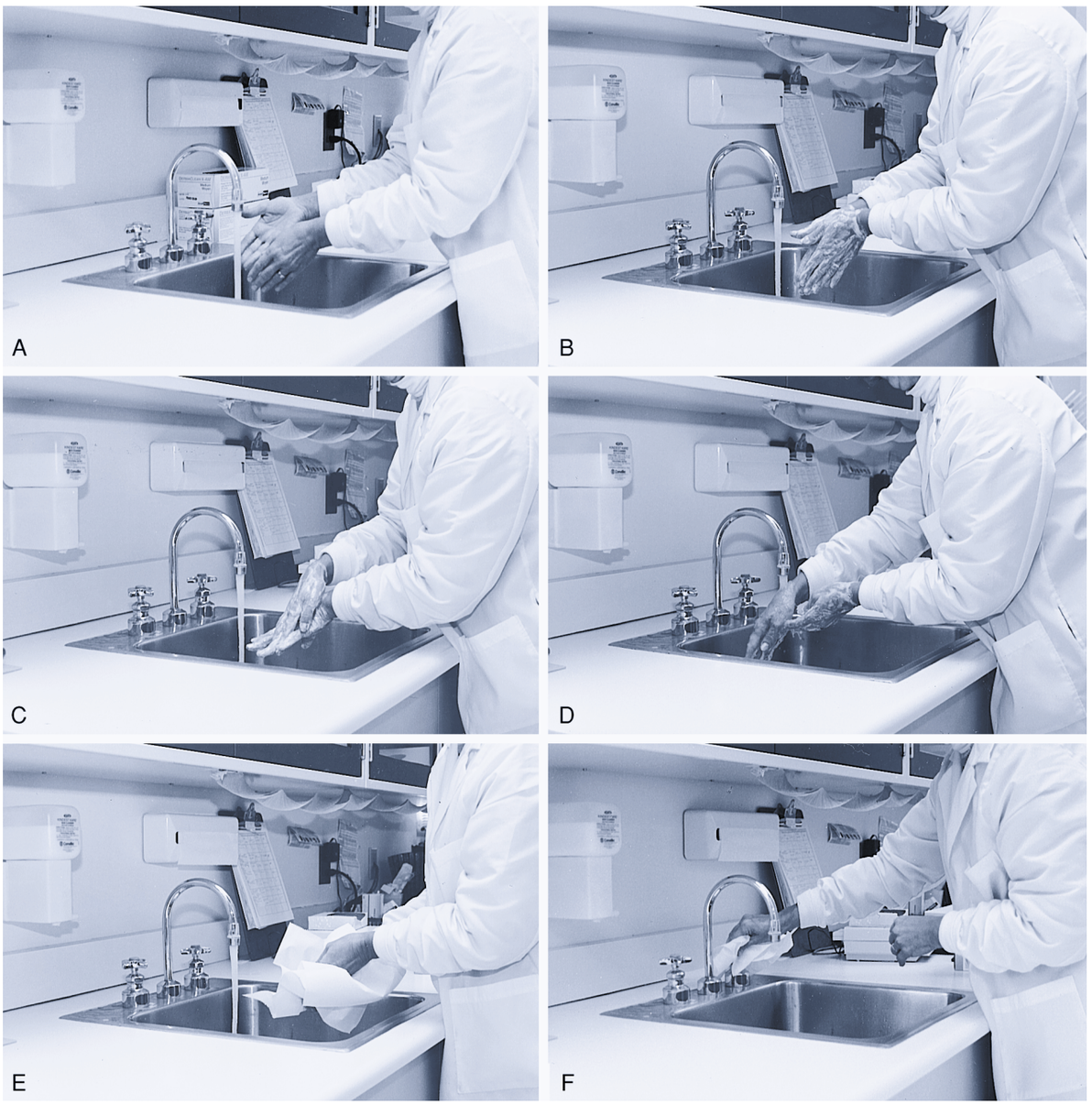


FIGURE 1–2 Handwashing technique. (*A*) Wetting hands. (*B*) Lathering hands and creating friction. (*C*) Cleaning between fingers. (*D*) Rinsing hands. (*E*) Drying hands. (*F*) Turning off water. (From Strasinger and DiLorenzo,[6] p 24, with permission.)

shields. Particular care should be taken to avoid splashes and aerosols when removing container tops, pouring specimens, and centrifuging specimens. Specimens must never be centrifuged in uncapped tubes or in uncovered centrifuges. Special precautions, which may include specimen rejection, must be taken when specimens are received in containers with contaminated exteriors.

HANDWASHING

Handwashing is emphasized in Figure 1–1 and in the Standard Precautions guidelines. Hand contact is the number-one method of infection transmission. Laboratory personnel must always wash hands after gloves are removed, prior to leaving the work area, at any time when hands have been knowingly contaminated, and before going to designated break areas, as well as before and after using bathroom facilities.

Correct handwashing technique is shown in Figure 1–2 and includes the following steps:

1. Wet hands with warm water.
2. Apply antimicrobial soap.
3. Rub to form a lather, create friction, and loosen debris.
4. Thoroughly clean between fingers, under fingernails and rings, and up to the wrist for at least 15 seconds.
5. Rinse hands in a downward position.
6. Dry with a paper towel.
7. Turn off faucets with the used paper towel to prevent recontamination.

DISPOSAL OF BIOLOGICAL WASTE

All biological waste, except urine, must be placed in appropriate containers labeled with the biohazard symbol (see Fig. 1–1). This includes not only specimens, but also the materials with which the specimens come in contact. The waste is then decontaminated following institutional policy: incineration, autoclaving, or pickup by a certified hazardous waste company.

Urine may be discarded by pouring it into a laboratory sink. Care must be taken to avoid splashing and the sink should be flushed with water after specimens are discarded. Disinfection of the sink using a 1:5 or 1:10 dilution of sodium hypochlorite should be performed on a daily basis. Sodium hypochlorite dilutions are effective for 1 week after preparation. The same solution also can be used for routinely disinfecting countertops and when accidental spills occur. Absorbent materials used for cleaning countertops and removing spills must be discarded in biohazard containers.

Sharp Hazards

Sharp objects in the laboratory, including needles, lancets, and broken glassware, present a serious biological hazard, particularly for the transmission of bloodborne pathogens. All sharp objects must be disposed of in puncture-resistant containers, such as those shown in Figure 1–3. Puncture-resistant containers should be conveniently located within the work area.

FIGURE 1–3 Examples of puncture-resistant containers. (From Strasinger and DiLorenzo,[5] p 67, with permission.)

Chemical Hazards

The same general rules for handling biohazardous materials apply to chemically hazardous materials; that is, to avoid getting these materials in or on bodies, clothes, or work area. Every chemical in the work place should be presumed hazardous.

CHEMICAL SPILLS

When skin contact occurs, the best first aid is to flush the area with large amounts of water. For this reason, all laboratory personnel should know the location of emergency showers and eye wash stations. Contaminated clothing should be removed as soon as possible. No attempt should be made to neutralize chemicals that come in contact with the skin. Chemical spill kits containing protective apparel, nonreactive absorbent material, and bags for disposal of contaminated materials should be available for cleaning up spills.

CHEMICAL HANDLING

Chemicals should never be mixed together, unless specific instructions are followed, and they must be added in the order specified. This is particularly important when combining acid and water; acid should always be added to water to avoid the possibility of sudden splashing. Wearing goggles and preparing reagents under a fume hood is a recommended safety precaution. Chemicals should be used from containers that are of an easily manageable size. Pipetting by mouth is unacceptable in the laboratory. State and federal regulations are in place for the disposal of chemicals and should be consulted.

CHEMICAL HYGIENE PLAN

OSHA also requires all facilities that use hazardous chemicals to have a written ***Chemical Hygiene Plan*** (**CHP**) available to employees.[4] The purpose of the plan is to detail the following:

1. Appropriate work practices
2. Standard operating procedures
3. Personal protective equipment

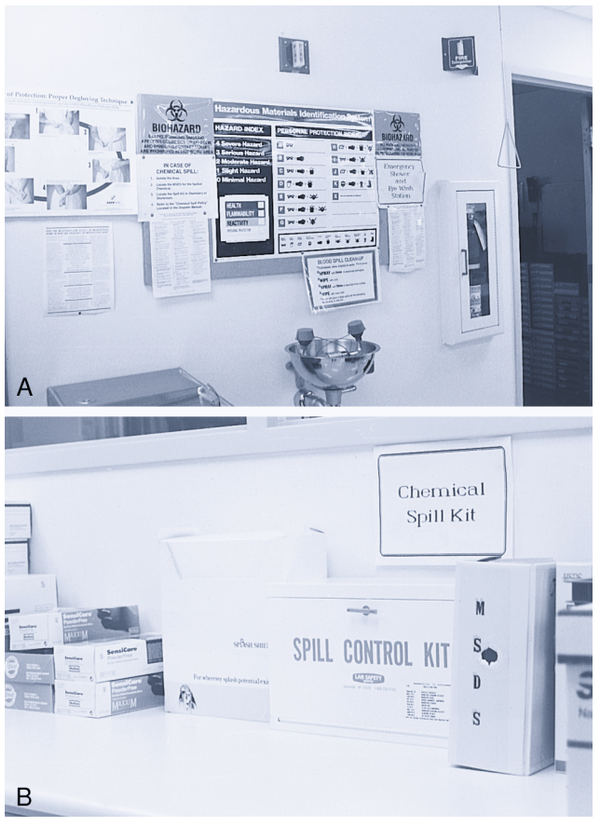


FIGURE 1–4 Chemical safety aids. (*A*) Equipment. (*B*) Information and supplies. (From Strasinger and DiLorenzo,[6] p 34, with permission.)

FIGURE 1–5 NFPA Hazardous material symbols.

4. Engineering controls, such as fume hoods and flammables safety cabinets
5. Employee training requirements
6. Medical consultation guidelines

Each facility must appoint a chemical hygiene officer, who is responsible for implementing and documenting compliance with the plan. Examples of required safety equipment and information are shown in Figure 1–4.

CHEMICAL LABELING

Hazardous chemicals should be labeled with a description of their particular hazard, such as poisonous, corrosive, or **carcinogenic**. The National Fire Protection Association (**NFPA**) has developed the Standard System for the Identification of the Fire Hazards of Materials, NFPA 704.[2] This symbol system is used to inform fire fighters of the hazards they may encounter with fires in a particular area. The diamond-shaped, color-coded symbol contains information relating to health, flammability, reactivity, and personal protection/special precautions. Each category is graded on a scale of 0 to 4, based on the degree of concern. These symbols are placed on doors, cabinets, and containers. An example of this system is shown in Figure 1–5.

MATERIAL DATA SAFETY SHEETS

The OSHA Federal Hazard Communication Standard requires that all employees have a right to know about all chemical hazards present in their workplace. The information is provided in the form of ***Material Safety Data Sheets*** **(MSDSs)** on file in the workplace. By law, vendors are required to provide these sheets to purchasers; however, the facility itself is responsible for obtaining and making MSDSs available to employees. Information contained in an MSDS includes the following:

1. Physical and chemical characteristics
2. Fire and explosion potential
3. Reactivity potential
4. Health hazards
5. Methods for safe handling

Radioactive Hazards

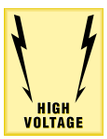
Radioactivity is encountered in the clinical laboratory when procedures using ***radioisotopes*** are performed. The amount of radioactivity present in the clinical laboratory is very small and represents little danger; however, the effects of radiation are cumulative related to the amount of exposure. The degree of radiation exposure is related to a combination of time,

FIGURE 1–6 Film badge. (From Strasinger and DiLorenzo,[6] p 436, with permission.)

distance, and shielding. Persons working in a radioactive environment are required to wear measuring devices to determine the amount of radiation they are accumulating (Fig. 1–6).

Laboratory personnel should be familiar with the radioactive hazard symbol in the margin. This symbol must be displayed on the doors of all areas where radioactive material is present. Exposure to radiation during pregnancy presents a danger to the fetus; personnel who are pregnant, or think they may be, should avoid areas with this symbol.

Electrical Hazards



The laboratory setting contains a large amount of electrical equipment with which workers have frequent contact. The same general rules of electrical safety observed outside the workplace apply. The danger of water or fluid coming in contact with equipment is greater in the laboratory setting. Equipment should not be operated with wet hands. Designated hospital personnel closely monitor electrical equipment; however, laboratory personnel should continually observe for any dangerous conditions, such as frayed cords and overloaded circuits, and report them to the appropriate persons. Equipment that has become wet should be unplugged and allowed to dry completely before reusing. Equipment also should be unplugged before cleaning. All electrical equipment must be grounded with three-pronged plugs.

When an accident involving electrical shock occurs, the electrical source must be immediately removed. This must be done without touching the person or the equipment involved to avoid transference of the current to you. Turning off the circuit breaker, unplugging the equipment, or moving the equipment using a nonconductive glass or wood object are safe procedures to follow.

Fire/Explosive Hazards

The Joint Commission on Accreditation of Healthcare Organizations (**JCAHO**) requires that all health-care institutions post evacuation routes and detailed plans to follow in the event of a fire. Laboratory personnel should be familiar with these procedures. When a fire is discovered, all employees are expected to take the actions outlined in the mnemonic RACE.

Rescue—rescue anyone in immediate danger.
Alarm—activate the institutional fire alarm system.
Contain—close all doors to potentially affected areas.
Extinguish—attempt to extinguish the fire, if possible.

As discussed previously, laboratory workers often use potentially volatile or explosive chemicals that require special procedures for their handling and storage. Flammable chemicals should be stored in safety cabinets and explosion-proof refrigerators, and cylinders of compressed gas should be located away from heat and securely fastened to a stationary device to prevent accidental capsizing. Fire blankets must be present in the laboratory. Persons with burning clothes should be wrapped in the blanket to smother the flames.

The NFPA classifies fires with regard to the type of burning material. It also classifies the type of fire extinguisher that is used to control them. This information is summarized in Table 1–2. The multipurpose ABC fire extinguishers are the most common, but the label should always be checked before using.

TABLE 1–2 **Types of Fires and Fire Extinguishers**

Fire Type	Composition of Fire	Type of Fire Extinguisher	Extinguishing Material
Class A	Wood, paper, or clothing	Class A	Water
Class B	Flammable organic chemicals	Class B	Dry chemicals, carbon dioxide, foam, or halon
Class C	Electrical	Class C	Dry chemicals, carbon dioxide, or halon
Class D	Combustible metals	None	Sand or dry powder
		Class ABC	Dry chemicals

From Strasinger and DiLorenzo,[5] p 70, with permission.

Physical Hazards

Physical hazards are not unique to the laboratory, and routine precautions observed outside the workplace apply. General precautions to consider are to avoid running in rooms and hallways, watch for wet floors, bend the knees when lifting heavy objects, keep long hair pulled back, avoid dangling jewelry, and maintain a clean, organized work area. Closed-toe shoes that provide maximum support are essential for safety and comfort.

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3. Occupational Exposure to Blood-Borne Pathogens, Final Rule. Federal Register 29 (Dec 6), 1991.
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5. Strasinger, SK, and DiLorenzo, MA: Phlebotomy Workbook for the Multiskilled Healthcare Professional. FA Davis, Philadelphia, 1996.
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STUDY QUESTIONS

1. List an example of each of the following health-care hazards that can be found in the clinical laboratory: biological, sharp, chemical, radioactive, electrical, fire/explosive, and physical.
2. List the three components of the chain of infection and give an example of each that could be found in the urinalysis laboratory.
3. What was the primary purpose for the CDC Universal Precautions guideline?
4. Which of the following guidelines provides the least protection for a person performing urinalysis? Why?
   a. Body substance isolation
   b. Universal Precautions
   c. Standard Precautions
5. A laboratory that fails to provide its employees with an adequate supply of gloves is in danger of being fined by _____.
6. A laboratory worker notices a red rash on the hands after removing his or her gloves. Should the worker be concerned? Why or why not?
7. What is the purpose of a Plexiglas shield on the urinalysis laboratory counter?
8. For what two purposes is a paper towel used when washing the hands?
9. Name a biological waste that does not have to be discarded in a biohazard container.
10. A urine specimen is accidentally overturned on the countertop. Where should the towels used to absorb the spill be discarded? Describe an acceptable disinfectant.
11. What is the correct way to dispose of a glass cylinder that is broken while being cleaned?
12. When a caustic solution such as phenol is spilled on the skin, what is the recommended first aid?
13. When preparing a 1:10 dilution of hydrochloric acid, in what order should the hydrochloric acid and water be added? Why?
14. How can an employee learn the carcinogenic potential of phenol?
15. What are the locations of the following: MSDS, Chemical Hygiene Plan, and NFPA symbols.
16. What is the significance of an NFPA symbol labeled: 4 - 4 - 4 - ~~w~~?
17. When should a laboratory worker avoid performing tests using radioisotopes?
18. List three ways to remove the source of an electrical shock.
19. State the RACE actions to be performed when a fire is discovered.
20. What type of fire can be extinguished using water?