ASSISTING IN THE CLINICAL LABORATORY

SCENARIO

Marsha Rollins has been employed for 3 years as a certified medical assistant in a medical practice. The physicians have a medical laboratory on site, and Marsha has become experienced in collecting specimens, performing laboratory tests, and reporting results. Recently she was offered a position in a smaller practice closer to home; she has accepted the position, knowing that her experience will benefit the practice because the physicians would like to expand their on-site medical laboratory testing, and Marsha will be required to equip the laboratory.

While studying this chapter, think about the following questions:

- What agencies can assist Marsha as she researches the feasibility of setting up a laboratory in the physicians’ office?
- What regulations will guide the testing that will be performed in the lab?
- What equipment will she need and how will she ensure that it remains in good working order?

LEARNING OBJECTIVES

1. Define, spell, and pronounce the terms listed in the vocabulary.
2. Apply critical thinking skills in performing the patient assessment and patient care.
3. Discuss the role of the clinical laboratory in patient care and the medical assistant’s role in coordinating laboratory tests and results.
4. Describe the divisions of the clinical laboratory and give an example of a test performed in each division.
5. Describe the Clinical Laboratory Improvement Amendments (CLIA) and how they influence laboratory testing.
6. Explain the three CLIA regulatory categories.
7. Compare and contrast the agencies that govern or influence practice in the clinical laboratory, including the Centers for Disease Control and Prevention (CDC), the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the Clinical and Laboratory Standards Institute (CLSI), and the College of American Pathologists (CAP).
8. Summarize techniques to minimize physical, chemical, and biologic risks in the clinical laboratory.
9. Describe the essential elements of a laboratory requisition.
10. Display sensitivity to patients’ rights and feelings in collecting specimens.
11. Explain chain of custody and illustrate why it is important.
12. Compare and contrast quality assurance and quality control.
13. Describe the differences between Greenwich time and military time.
14. Identify the Fahrenheit temperature and Celsius temperature of common laboratory equipment.
15. Name the metric units used for measuring liquid volume, distance, and mass.
16. Describe the proper use of pipets.
17. Explain how dilutions are prepared.
18. Name the parts of a microscope, and describe their functions.
19. Summarize selected microscopy tests that can be performed in the ambulatory care setting.
20. Demonstrate the proper use of the microscope.
21. Describe the safe use of a centrifuge.
VOCABULARY

**aliquot** (ə-luh-kwahlt) A portion of a well-mixed sample removed for testing.

**analyte** The substance or chemical being analyzed or detected in a specimen.

**anticoagulants** Chemicals added to a blood sample after collection to prevent clotting.

**caustic** (kōs′-tik) Capable of burning, corroding, or damaging tissue by chemical action.

**cytology** (sī-təl′-ə-je) The study of cells using microscopic methods.

**diluent** (dil-yuh-wunt) A liquid used to dilute a specimen or reagent.

**exudates** (ek′-syu-dats) Fluids with a high concentration of protein and cellular debris that have escaped from the blood vessels and have been deposited in tissues or on tissue surfaces.

**hemolyzed** A term used to describe a blood sample in which the red blood cells have ruptured.

**preservatives** Substances added to a specimen to prevent deterioration of cells or chemicals.

**referral laboratory** A private or hospital-based laboratory that performs a wide variety of tests, many of them specialized; physicians often send specimens collected in the office to referral laboratories for testing.

**specimen** A sample of body fluid, waste product, or tissue that is collected for analysis.

Laboratory medicine, or clinical pathology, is the medical discipline that applies clinical laboratory science and technology to the care of patients. The laboratory is the place in which a collected specimen is analyzed and evaluated. Tests are performed manually (by hand) or through automation (by using specialized instruments).

**Role of the Clinical Laboratory in Patient Care**

**Personnel in the Clinical Laboratory**

Medical laboratories are located either in hospitals or in facilities such as physicians’ offices, clinics, public health departments, health maintenance organizations, and private referral laboratories. The director of a laboratory may be a pathologist, a physician specially trained in the nature and cause of disease, or a clinical laboratory scientist with a doctorate. The laboratory is staffed by various professionally trained individuals, including certified medical technologists (MTs), who have earned a baccalaureate degree, have had additional formal training, and have passed a national certification examination. Other personnel include certified medical laboratory technicians (MLTs) or medical laboratory assistants (MLAs) and certified medical assistants (CMA). These employees have completed a 1- to 2-year specialized training program and have passed a registry examination. Laboratory assistants and phlebotomists, who have received specialized training in the collection and preparation of laboratory specimens, also work in laboratories. The agencies granting certifications and titles are described in Table 51-1.

The medical assistant is trained to perform certain testing procedures, as well as in methods of collecting specimens that are sent to outside reference laboratories for testing. Laboratory tests are an essential part of a medical diagnosis, and they help the physician determine the most appropriate treatment. In addition, they may be performed to help the physician decide which medication to prescribe and to monitor the effects of medications. Only healthcare practitioners may request laboratory testing for a patient. The medical assistant may be responsible for a number of these testing procedures. To assume this responsibility, the medical assistant must know proper patient preparation, the procedures for each test, and the normal range of results for the test. The medical assistant must carefully follow all laboratory instructions in obtaining and labeling the specimens and sending them to the laboratory. Good communication among the patient, the office staff, and laboratory personnel is important. The medical assistant should make the patient feel more at ease with these procedures and thus gain the patient’s cooperation.

**Clinical Laboratory Testing**

Clinical laboratory testing is used in conjunction with a thorough health history and physical examination to provide essential data for the diagnosis and management of a patient’s condition. The body is considered to be healthy when a state of equilibrium exists in the internal environment. In this state, called homeostasis, the physical and chemical characteristics of body substances (e.g., fluids, secretions, and excretions) are within a certain acceptable range, known as the normal or reference range. A change in homeostasis results in abnormal test values (i.e., outside of the reference range). Abnormal values for a particular test may be seen with more than one pathologic condition. For example, a decrease in hemoglobin levels in red blood cells (RBCs) is seen in iron-deficiency anemia, but also in hyperthyroidism and cirrhosis of the liver. Therefore, physicians cannot rely solely on laboratory tests to make a diagnosis; they must use a combination of data obtained from the health history, physical examination, and a number of diagnostic and laboratory results.

Tests performed in a clinical laboratory range from simple screening tests to complex profile testing. A screening test examines a particular specimen for the presence of a substance that may indicate a disease state. These types of tests are not diagnostic for any particular disease, but rather indicate that the disease state may exist. Screening tests are done routinely on patients based on their age, history, or gender. They often are qualitative in that a numeric value is not attached to the result; results may simply be reported as positive or negative. The fecal occult blood test for hidden or microscopic blood in the stool is an example of a screening test. Blood is not normally found in the stool, and its
TABLE 51-1 Certifying Agencies for Laboratory Personnel

<table>
<thead>
<tr>
<th>CERTIFYING AGENCY</th>
<th>TITLE</th>
<th>POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Society for Clinical Pathologists</td>
<td>MT (ASCP)</td>
<td>Medical technologist</td>
</tr>
<tr>
<td></td>
<td>MLT (ASCP)</td>
<td>Medical laboratory technician — certificate</td>
</tr>
<tr>
<td></td>
<td>MLT-AD (ASCP)</td>
<td>Medical laboratory technician — associate's degree</td>
</tr>
<tr>
<td>American Medical Technologists</td>
<td>MT (AMT)</td>
<td>Medical technologist</td>
</tr>
<tr>
<td></td>
<td>MLT (AMT)</td>
<td>Medical laboratory technician</td>
</tr>
<tr>
<td>Department of Health and Human Services</td>
<td>CLT (HHS)</td>
<td>Clinical laboratory technologist</td>
</tr>
<tr>
<td>National Certification Agency for Medical Laboratory Personnel</td>
<td>CLS (NCA)</td>
<td>Certified laboratory scientist</td>
</tr>
<tr>
<td></td>
<td>CLT (NCA)</td>
<td>Certified laboratory technician</td>
</tr>
<tr>
<td>International Society for Clinical Laboratory Technology</td>
<td>RMT (ISCLT)</td>
<td>Registered medical technologist</td>
</tr>
<tr>
<td></td>
<td>RLT (ISCLT)</td>
<td>Registered laboratory technician</td>
</tr>
<tr>
<td>American Association of Medical Assistants (AAMA)</td>
<td>CMA (AAMA)</td>
<td>Certified medical assistant</td>
</tr>
<tr>
<td>Accrediting Bureau of Health Education Schools</td>
<td>RMA</td>
<td>Registered medical assistant (AMT)</td>
</tr>
<tr>
<td>California Certifying Board for Medical Assistants</td>
<td>CCMA-C (CCBMA)</td>
<td>California certified medical assistant—clinical</td>
</tr>
<tr>
<td>National Healthcare Association (NHA)</td>
<td>CCMA</td>
<td>Certified clinical medical assistant</td>
</tr>
<tr>
<td></td>
<td>CPT</td>
<td>Certified phlebotomy technician</td>
</tr>
<tr>
<td></td>
<td>CML</td>
<td>Certified medical laboratory assistant</td>
</tr>
</tbody>
</table>

presence may indicate a cancerous lesion in the colon. A positive test result indicates that blood is present, but additional testing is required to determine the source of the blood. For example, further testing or examination may reveal that the patient had her menstrual period at the time of collection of the specimen or that she had bleeding hemorrhoids.

In a quantitative test, units of measure are attached to numeric values. These values often are represented as the amount of analyte per given volume of specimen, and it is essential that the results be reported with the units of measure. For example, in a complete blood cell count for a healthy adult, the RBCs number 5 million per cubic millimeter \( (5 \times 10^{12}/\text{mm}^3) \), the hemoglobin value is 15 grams per deciliter \( (15 \text{ g/dL}) \), and the hematocrit is 45%. Generally the units are printed on the laboratory report, but the medical assistant must always make sure the values are consistent with the test performed.

CRITICAL THINKING APPLICATION 51-1

The referral laboratory telephones to report the values on several tests performed on the urine of a patient, Cecilia Roberts. Marsho jots down the following: Total protein, 0.12; Occult blood, positive; Albumin, 50; Glucose, 120. What is wrong with the notations she has just made? Are these tests qualitative or quantitative?

Clinical Laboratory Improvement Amendments

In 1988 Congress passed the Clinical Laboratory Improvement Amendments (CLIA), establishing quality standards for all laboratory testing to ensure the accuracy, reliability, and timeliness of patient test results regardless of where the test is performed. A laboratory is defined as any facility that performs laboratory testing on specimens derived from humans for the purpose of providing information about the diagnosis, prevention, and treatment of disease or impairment of or assessment of health. The CLIA program is user-fee funded; therefore, all costs of administering the program must be covered by the regulated facilities. CLIA requires all entities that perform even one test, including waived tests, to meet certain federal requirements and to register as a laboratory. An application must be submitted that reports information about a laboratory’s operation. The type of certificate to be issued and the fees to be assessed are determined from this information.

The CLIA categorization of commercially marketed in vitro diagnostic tests now is the responsibility of the U. S. Food and Drug Administration (FDA). The FDA has assumed primary responsibility for performing the CLIA complexity categorization functions, which include the process of assigning commercially marketed in vitro diagnostic test systems to one of three CLIA regulatory categories based on their potential risk to public health: waived tests, moderate-complexity tests, and high-complexity tests.

Waived Tests

Waived tests (Table 51-2) include the following:

Laboratory examinations and procedures that have been approved by the Food and Drug Administration for home use or that, as determined by the Secretary, are simple laboratory examinations and procedures that have an insignificant risk of an erroneous result, including those that (A) employ methodologies that are so simple and accurate to render the likelihood of erroneous results by the user negligible, or (B) the Secretary has determined pose no unreasonable risk of harm to the patient if performed incorrectly.

A CLIA database is available to the public on the Internet. This database contains the commercially marketed in vitro test
<table>
<thead>
<tr>
<th>TEST</th>
<th>PURPOSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dipstick or tablet reagent urinalysis (nonautomated) for bilirubin,</td>
<td>Urine screening to assess or diagnose diseases such as diabetes mellitus,</td>
</tr>
<tr>
<td>glucose, hemoglobin, ketone, leukocytes, nitrite, pH, protein, specific</td>
<td>kidney disease, and urinary tract infections</td>
</tr>
<tr>
<td>gravity, urobilinogen</td>
<td></td>
</tr>
<tr>
<td>Urine pregnancy tests: visual color comparison tests</td>
<td>Diagnosis of pregnancy</td>
</tr>
<tr>
<td>Urine chemistry analyzer; automated urine dipstick analysis</td>
<td>Urine screening to assess or diagnose diseases such as diabetes mellitus,</td>
</tr>
<tr>
<td></td>
<td>kidney disease, and urinary tract infections</td>
</tr>
<tr>
<td>Urine chemistry analyzer for microalbumin and creatinine</td>
<td>Detection of kidney disease</td>
</tr>
<tr>
<td>Ovulation tests: visual color comparison tests for luteinizing hormone</td>
<td>Detection of ovulation</td>
</tr>
<tr>
<td>Fecal occult blood</td>
<td>Colorectal screening to detect hidden blood in the stool</td>
</tr>
<tr>
<td>Erythrocyte sedimentation rate, nonautomated</td>
<td>Diagnosis of inflammatory process; increases in presence of arthritis,</td>
</tr>
<tr>
<td></td>
<td>infections, leukemia, and most cancers</td>
</tr>
<tr>
<td>Hemoglobin-copper sulfate, nonautomated</td>
<td>Measurement of blood hemoglobin levels</td>
</tr>
<tr>
<td>HemoCue Hemoglobin system</td>
<td>Measurement of hemoglobin level in whole blood</td>
</tr>
<tr>
<td>Blood glucose by glucose monitoring devices cleared by the FDA</td>
<td>Monitoring of blood glucose levels</td>
</tr>
<tr>
<td>specifically for home use</td>
<td></td>
</tr>
<tr>
<td>HemoCue B</td>
<td>Measurement of glucose levels in whole blood</td>
</tr>
<tr>
<td>Spun microhematocrit</td>
<td>Measurement of blood count; screening for certain types of anemia</td>
</tr>
<tr>
<td>STAT-CRIT hematocrit</td>
<td>Screening for certain types of anemia</td>
</tr>
<tr>
<td>Hemoglobin and hemoglobin A1 by single analyte instruments with self-</td>
<td>Measurement of A1 levels to assess and manage long-term care of patients</td>
</tr>
<tr>
<td>contained or component lecturers to perform specimen-reagent</td>
<td>with diabetes</td>
</tr>
<tr>
<td>interaction</td>
<td></td>
</tr>
<tr>
<td>Cholestech LDX</td>
<td>Measurement of total blood cholesterol, triglycerides, HDL, and glucose</td>
</tr>
<tr>
<td>Blood mononucleosis antibodies</td>
<td>levels</td>
</tr>
<tr>
<td><em>Helicobacter pylori</em> antibodies</td>
<td>Rapid qualitative test to detect antibodies to help diagnose infectious</td>
</tr>
<tr>
<td></td>
<td>mononucleosis</td>
</tr>
<tr>
<td><em>Borreli burgdorferi</em> antibodies</td>
<td>Rapid whole blood test to detect <em>H. pylori</em> antibodies to determine the cause of peptic ulcer</td>
</tr>
<tr>
<td>Whole blood OraSure HIV-1 test</td>
<td>Rapid whole blood test to detect <em>B. burgdorferi</em> antibodies to diagnose Lyme disease</td>
</tr>
<tr>
<td>Nasal influenza A and B</td>
<td>Detection of HIV-1 in blood specimen</td>
</tr>
<tr>
<td>Streptococcus A throat swab</td>
<td>Quick qualitative diagnosis of influenza antigens in nasal secretions or swab</td>
</tr>
<tr>
<td></td>
<td>Rapid strep test</td>
</tr>
</tbody>
</table>

**FDA, U.S. Food and Drug Administration; HDL, high-density lipoprotein; HIV-1, human immunodeficiency virus type 1.**

Systems categorized by the FDA since January 31, 2000, and tests categorized by the Centers for Disease Control and Prevention (CDC) before that date. The records can be searched by test system name, specialty or subspecialty, analyte, document number, qualifier, effective date, and complexity.

**Moderate- and High-Complexity Tests**

The CLIA program oversees the quality of nearly 200,000 different laboratory procedures. An estimated 10,000 different laboratory tests are performed in the United States every day; 75% of them are categorized by the FDA as moderate-complexity tests. Some of these tests are performed in physician’s office laboratories (POLs), including hematology and chemistry testing done on an automated analyzer, Gram staining, and microscopic analysis of urine sediment. High-complexity tests usually are not performed in a POL; these include Papanicolaou (Pap) smear analysis, blood typing and cross-matching, and cytologic testing.

Laboratories that perform moderate- to high-complexity testing must meet CLIA regulations and are subject to unannounced inspections every 2 years. Each laboratory that performs these tests must establish a system to maintain the integrity and identification of patients’ specimens throughout the testing process and to ensure accurate reporting of results. The laboratory also must have established and must follow written quality control (QC) and quality assurance (QA) procedures and must participate in proficiency testing, a form of external quality control. Three times a year the laboratory must test samples provided by an approved proficiency testing agency using the same tests the laboratory would use to test a patient’s sample. Finally, CLIA regulations specify qualifications and responsibi-
ties for personnel in the laboratory, from directors to testing personnel. Personnel requirements are most stringent for high-complexity testing.

Medical assistants may perform all CLIA-waived tests and some moderately complex tests, depending on the certification of the laboratory or POL in which they are employed. Although medical assistants may not perform high-complexity tests, they often are involved in collecting the specimens required, preparing the patient for the test, and recording the results in the medical record.

DIVISIONS OF THE CLINICAL LABORATORY

The laboratory is divided into various departments, which may include hematology, chemistry, microbiology, specimen collection and processing, blood bank, coagulation, serology, histology, cytology, toxicology, urinalysis, and special chemistry. The laboratory in the physician’s office usually performs procedures in urinalysis, hematology, chemistry, and microbiology.

Urinalysis

Urinalysis includes the physical, chemical, and microscopic examination of urine. In the physical examination, the color, clarity, and specific gravity are noted. Chemical analysis is performed to measure levels of such analytes as glucose, protein, ketones, blood, bilirubin, urobilinogen, nitrites, and pH. Microscopically the urine is examined for the presence of red, white, and epithelial cells, mucus, casts, crystals, yeasts, parasites, and bacteria. Additional quantitative tests may be performed in the urinalysis department to confirm routine screening tests.

Hematology

Tests performed in the hematology division may be qualitative or quantitative. Blood cell counts determine the exact number of RBCs or erythrocytes, white blood cells (WBCs, or leukocytes), or platelets (thrombocytes) either by manual or automated counting. Qualitative tests determine the characteristics of cells, such as size, shape, and maturity. In addition, the hematology department performs tests to determine the coagulating ability of blood components.

Chemistry

The clinical chemistry department analyzes blood, cerebrospinal fluid (CSF), urine, and joint fluid (synovial fluid). Procedures may include single tests or profiles, which include tests for a number of related analytes. Lipid profiles, for example, include assessments of total cholesterol, triglycerides, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol.

Microbiology

Microbiology involves the study of bacteria, fungi, yeasts, parasites, and viruses. In the microbiology laboratory, microorganisms are grown (cultured) from blood, urine, sputum, CSF, and wound specimens and are identified. Sensitivity testing then is performed on these organisms to determine the proper antibiotic therapy. Specimens for microbiology must be collected aseptically in sterile containers.

CRITICAL THINKING APPLICATION

Dr. Watkins has ordered a routine urinalysis (UA), a urine culture and sensitivity (C&S) test, a blood glucose test, and a complete blood count (CBC) for his patient. What division of the laboratory is responsible for analyzing the specimens for each test?

LABORATORY SAFETY

The importance of safety in the laboratory cannot be overemphasized. Most laboratory accidents can be prevented through the use of proper techniques and common sense. Following safe practices in the laboratory requires a personal commitment and concern for others; an unsafe act may harm an innocent bystander without harming the person who performs the act.

Safety Standards and Governing Agencies

Safety standards for laboratories are initiated, regulated, and reviewed by several agencies or committees. These include the U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA); the Clinical and Laboratory Standards Institute (CLSI, formerly the National Committee for Clinical Laboratory Standards), a nonprofit educational organization that provides a forum for the development, promotion, and use of national and international standards; the CDC, an agency of the U.S. Department of Health and Human Services; the College of American Pathologists (CAP), a leader in providing laboratory quality improvement programs; and the Environmental Protection Agency (EPA), a government agency charged with protecting human health and safeguarding the natural environment.

Through OSHA the government has created a system of safeguards and regulations under the Occupational Safety and Health Act of 1970. This system affects nearly every worker in the United States, because the regulations apply to all businesses with one or more employees. (The regulations are discussed in detail in Chapter 27.) Two programs have been mandated by OSHA to ensure the safety of personnel working in clinical laboratories. One covers occupational exposure to chemical hazards; the other covers exposure to blood-borne pathogens. Both of these programs, as they relate to safety in the medical laboratory setting, are discussed later in this chapter.

LABORATORY HAZARDS

Physical Hazards

Physical hazards in the laboratory can be classified as electrical, fire, and mechanical hazards. Electric shock is a threat when any electrical equipment is in use. It is imperative to keep all electrical equipment in proper repair and always to follow manufacturers’ instructions.

Use surge protectors; inspect all cords and plugs frequently, never use extension cords, and avoid overloading circuits. Unplug the electrical device before servicing and never operate electrical instruments with wet hands. If a sink is nearby, make sure electrical cords do not come in contact with the water supply. Signs and labels should be placed on specific electrical hazards (Figure 51-1).
Open flames are rarely used in a laboratory, but the potential for fire still exists. Fires may be ignited by smoking, heating elements, and sparks. Flammable materials should not be stored near any source of ignition. All laboratory personnel should be familiar with the location of fire extinguishers and fire safety blankets. Fire extinguishers should be the carbon dioxide (CO₂), dry chemical, or halon type, known as the ABC type of extinguisher. The ABC extinguisher can be used on all types of fires. These extinguishers should be inspected regularly by a licensed inspector and replaced or recharged if used. The medical assistant may be responsible for maintaining records on the care and maintenance of fire extinguishers.

Fire safety blankets should be used to smother flames on burning clothing. However, a victim should not be wrapped in a fire blanket, because this may intensify burns. Instead, the flames should be patted out or the victim directed to roll on the blanket.

Emergency phone numbers should be posted on the wall near the telephone, and all personnel should know the location of fire alarms, the fire escape routes, and procedures to follow if exits are blocked. Periodic fire drills should be conducted, and hallways and exits should be kept free of clutter.

Mechanical hazards arise from the use of laboratory equipment. Special care should be exercised when using equipment with moving parts, such as centrifuges, and those that rely on pressure, including autoclaves. Centrifuges, devices that separate liquids from solids, present a hazard not only from moving parts but also from glassware that might break during centrifugation and from aerosols that might be created if tubes are not capped tightly. Pressurized types of equipment, such as autoclaves used in sterilization, present a danger if opened prematurely. Although centrifuges and autoclaves often have built-in safeguards, such as locks that prevent entry until the environment is safe, improper care of the equipment can result in failure of the safety measures.

## Chemical Hazards

The clinical laboratory is home to chemicals that are flammable, caustic, poisonous, carcinogenic, and/or teratogenic. Exposure to these dangerous chemicals can occur through inhalation, direct absorption through the skin, ingestion, entry through a mucous membrane, or entry through a break in the skin. OSHA is involved in regulating the standards directed at minimizing occupational exposure to hazardous chemicals in laboratories. The OSHA hazard communication standard (known as the employee “right to know” rule) became law in 1991 and ensures that laboratory workers are fully aware of the hazards associated with their workplace. The law requires the development of a comprehensive plan to implement safe practice throughout the laboratory with regard to chemicals. This chemical hygiene plan must outline the specific work practices and procedures needed to protect workers from any health hazards that may arise from working with in-stock chemicals. All workers must be provided with information and training, and a material safety data sheet (MSDS) must be on file for all chemicals used in the laboratory. OSHA requires the manufacturer of the chemical to make the sheets available, usually as a package insert.

Each MSDS contains the basic information about the specific chemical or product. This includes the trade name, chemical name and synonyms, chemical family, manufacturer's name and address, emergency telephone number, hazardous ingredients, physical data, fire and explosion data, and health hazard and protection information (Figure 51-2).

Following principles of proper handling reduces the risks of harmful effects. Harmful exposure can be reduced by using proper devices for pipetting; never pipet by mouth. If a chemical produces toxic or flammable vapors, work under a fume hood that exhausting air to the outside. In case of accidental exposure of the skin, rinse the affected area under running water for at least 5 minutes. Remove any contaminated clothing. If chemicals are splashed in the eyes, flush the eyes with water from an eyewash station for a minimum of 15 minutes. Prompt medical attention must be given to victims of chemical exposure.

Chemicals should be tightly sealed and properly labeled. A hazard identification system has been developed by the National Fire Protection Association that provides information at a glance on the potential health, flammability, and chemical reactivity hazards of materials. This identification system consists of four small, colored, diamond-shaped symbols grouped into a larger diamond shape. The top diamond is red and indicates a flammability hazard. The diamond on the left is blue and indicates hazards to health. The bottom diamond is white and provides special hazard information, including radioactivity, special biohazards, and other hazardous situations. The diamond on the right is yellow and indicates a reactivity or stability hazard. The system indicates the severity of the hazard by using numbers imprinted in the diamonds from 0 to 4, with 0 representing no hazard and 4 representing an extremely hazardous substance (Figure 51-3).

### Biologic Hazards and Infection Control

Biologic hazards, or biohazards, are materials or situations that present a risk or potential risk of infection. Infection with biohazardous material can occur during specimen collection, handling, transportation, or testing. Potentially infective specimens include blood, body tissue biopsy specimens, urine, exudates, and bacterial cultures and smears. Infection can occur through aspiration of a pathogen, accidental inoculation by a needle stick, aerosols created by uncapping specimen tubes, centrifuge accidents, and entry of pathogens through cuts and scratches.

One of the most important OSHA regulations covers exposure to biologic hazards. The OSHA-mandated program, Occu-
### MATERIAL SAFETY DATA SHEET

**SECTION 1 IDENTIFICATION**
- **MANUFACTURER'S NAME:** Corells Corporation
  - **ADDRESS:** P.O. Box 93, Camden, NJ 08106

- **IDENTITY:** 2% Aqueous Glutaraldehyde Solution
- **PRODUCT CODE:** 3345
- **TRADE NAME:** Aldehyde
- **SYNONYMS:** None
- **CHEMICAL FAMILY:** Aldehydes
- **MOLECULAR FORMULA:** OHCC\textsubscript{3}H\textsubscript{2}CHO (Active)
- **MOLECULAR WEIGHT:** 100
- **HAZARD RATING – HEALTH:** 3 (Serious Hazard)
- **FLAMMABILITY:** 0
- **REACTIVITY:** 0
- **SPECIFIC:** NONE
- **EMERGENCY TELEPHONE NUMBER:** 1 (800) 733-8690
- **TELEPHONE NUMBER FOR INFORMATION:** 1 (800) 331-0766
- **ISSUED:** 10/99
- **PREPARED BY:** Regulatory Affairs

**SECTION 2 HAZARDOUS INGREDIENTS/IDENTITY INFORMATION**

<table>
<thead>
<tr>
<th>COMPONENTS (SPECIFIC CHEMICAL IDENTITY)</th>
<th>CAS #</th>
<th>%</th>
<th>OSHA PEL</th>
<th>ACGIH TLV</th>
<th>OSHA 1910.1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glutaraldehyde (active)</td>
<td>111-30-8</td>
<td>2</td>
<td>0.2ppm, C</td>
<td>0.2ppm, C</td>
<td>n/a</td>
</tr>
<tr>
<td>Inert buffer salts</td>
<td>n/a</td>
<td></td>
<td>None</td>
<td>None</td>
<td>Nonhazardous</td>
</tr>
<tr>
<td>Water</td>
<td>7732-18-5</td>
<td>98</td>
<td>None</td>
<td>None</td>
<td>Nonhazardous</td>
</tr>
</tbody>
</table>

**SECTION 3 PHYSICAL/CHEMICAL CHARACTERISTICS**
- **APPEARANCE AND ODOR:** 2 components: colorless fluid and liquid salts; turns green when activated. Sharp odor masked with peppermint fragrance.
- **BOILING POINT:** 212°F
- **SPECIFIC GRAVITY (H\textsubscript{2}O=1):** 1.003 g/cc
- **VAPOR PRESSURE (mm Hg):** same as water
- **MELTING POINT:** n/a
- **VAPOR DENSITY (Air=1):** same as water
- **EVAPORATION RATE (H\textsubscript{2}O=1):** 0.98
- **SOLUBILITY IN WATER:** complete
- **pH:** 8
- **FREEZING POINT:** same as water
- **ODOR THRESHOLD:** .04 ppm, detectable. (ACGIH)

**SECTION 4 FIRE AND EXPLOSION HAZARD DATA**
- **FLASH POINT (METHOD USED):** None
- **FLAMMABLE LIMITS – LEL:** nd
- **UEL:** nd
- **EXTINGUISHING MEDIA:** If water is evaporated, material can burn. Use carbon dioxide or dry chemical for small fires. Use foam (alcohol, polymer or ordinary) or water fog for large fires.
- **SPECIAL FIRE FIGHTING PROCEDURES:** Self-contained breathing apparatus and protective clothing should be available to fireman.
- **UNUSUAL FIRE AND EXPLOSION HAZARDS:** None
- **TOXIC GASES PRODUCED:** None

**SECTION 5 REACTIVITY DATA**
- **STABILITY:** 212°F
- **CONDITIONS TO AVOID:** None
- **INCOMPATIBILITY (MATERIALS TO AVOID):** None
- **HAZARDOUS DECOMPOSITION OR BYPRODUCTS:** None
- **HAZARDOUS POLYMERIZATION:** Will not occur

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**FIGURE 51-2** Material safety data sheet (MSDS). (From Bonewit-West K. Clinical procedures for medical assistants, ed 7, St. Louis, 2008, Saunders.)
## MATERIAL SAFETY DATA SHEET

### SECTION 6  HEALTH HAZARD DATA

**ROUTE(S) OF ENTRY**
- **INHALATION:** yes
- **SKIN:** yes
- **INGESTION:** yes
- **EYE:** yes

**SIGNS AND SYMPTOMS OF EXPOSURE:**
- **EYES:** Contact with eyes causes damage.
- **SKIN:** Can cause skin sensitization. Avoid skin contact.
- **INHALATION:** Vapors may be irritating and cause headache, chest discomfort, symptoms of bronchitis.
- **INGESTION:** May cause nausea, vomiting and general systemic illness.

**EMERGENCY AND FIRST AID PROCEDURE:**
- **EYES:** Flush thoroughly with water. Get medical attention.
- **SKIN:** Flush thoroughly with water. If irritation persists, get medical attention.
- **INHALATION:** Remove to fresh air. If symptoms persist, get medical attention.
- **INGESTION:** Do not induce vomiting. Drink copious amount of milk. Get medical attention.

**HEALTH HAZARDS (ACUTE AND CHRONIC):**
- **Acute:** As listed above under Signs and Symptoms of Exposure
- **Chronic:** None known from currently available information.

**MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:** None known from currently available information.

**LISTED AS CARCINOGEN BY**
- **NTP:** yes
- **IARC MONOGRAPHS:** no
- **OSHA:** no

**TOXICITY:**
- **ORAL LD50 (Rat):** Toxicity Rating 1: 500-5000 mg/kg.
- **OCULAR (Rabbit):** Toxicity Rating 2: Irritating or moderately persisting more than seven days with.
- **DERMAL LD50 (Rabbit):** None by dermal route.
- **INHALATION LC50 (Rabbit):** Irritating but non-toxic at highest concentration achieved (2.89 ppm).

### SECTION 7  PRECAUTIONS FOR SAFE HANDLING AND USE

**STEPS TO BE TAKE IN CASE MATERIAL IS RELEASED OR SPILLED:** For LARGE spills, use ammonium carbonate to "neutralize" glutaraldehyde odor. Collect liquid and discard it. For SMALL spills, wipe with sponge or mop down area with an equal mixture of household ammonia and water. Flush with large quantities of water.

**WASTE DISPOSAL METHOD:** Triple rinse empty container with water and dispose in an incinerator or landfill approved for pesticide containers. Discard solution with large quantities of water.

**EPA HAZARDOUS WASTE NUMBER:** n/a

**PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:** Use normal storage and handling requirements.

### SECTION 8  TRANSPORTATION DATA AND ADDITIONAL INFORMATION

**DOMESTIC (D.O.T):** Aldehydes, N.O.S.

**INTERNATIONAL (I.M.O):** Aldehydes, N.O.S.

**PROPER SHIPPING NAME:** Glutaraldehyde

**PROPER SHIPPING NAME:** Glutaraldehyde

**HAZARD CLASS:** None

**HAZARD CLASS:** None

**LABELS:** None Needed

**LABELS:** None Needed

**REPORTABLE QUANTITY:** None

**REPORTABLE QUANTITY:** None

**UN/NA:** 1989

**FIGURE 51-2, cont’d**
### MATERIAL SAFETY DATA SHEET

**SECTION 9  CONTROL MEASURES**

**VENTILATION:**
- **ROUTINE:** Product should be used in a covered container. Use with standard room ventilation (air conditioning); natural draft.
- **EMERGENCY:** Enhanced ventilation.

**RESPIRATORY PROTECTION:**
- **ROUTINE:** None required
- **EMERGENCY:** Organic vapor cartridge, canister mask.

**EYE PROTECTION:**
- **ROUTINE:** Safety glasses recommended
- **EMERGENCY:** Safety glasses

**SKIN PROTECTION:**
- **ROUTINE:** Impervious gloves
- **EMERGENCY:** Impervious gloves; Protective clothing; Rubber boots

**WORK/HYGIENIC PRACTICES:** Avoid contamination of food.

### SECTION 10  SPECIAL REQUIREMENTS

None

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**KEY:**
- n/a = Not Applicable
- nd = Not Determined
- C = Ceiling
- **PEL** = Permissible Exposure Level
- RTECS = Registry of Toxic Effects of Chemical Substances
- * = Trademark

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### FIGURE 51-2, cont’d.

Percutaneous Exposure to Bloodborne Pathogens, must be in place and has been law since 1992 as part of a general infection control policy. In addition, the CDC recommends safety precautions regarding handling of all patient specimens. Previously known as Universal Precautions, they are now referred to as Standard Precautions and are published on the organization’s Web page and in the publication Morbidity and Mortality Weekly Report. Chapter 27 covers the specifics of the OSHA-mandated programs.

The recommendations from the CDC include an infection control plan, engineering and work practice controls, personal protective clothing and equipment, sufficient training and education, provision of vaccination against hepatitis B, and medical intervention after exposure incidents. The CLSI also has guidelines for the laboratory worker with regard to protection from blood-borne illness caused by contact with patients’ specimens. The CAP offers a voluntary accreditation program for clinical laboratories that includes biosafety measures. One important precaution that can be taken is labeling of potentially biohazardous material, as described in Chapter 27.

### Standard Precautions

The hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) are a constant threat to the health and safety of clinical laboratory personnel. HBV, HCV, and HIV are transmitted through exposure to blood and body fluids. Blood and body fluids are the primary substances handled in the laboratory. OSHA mandated the Bloodborne Pathogens (BBP) Standard, which covers all employees who could be “reasonably anticipated as the result of performing their job duties to face contact with blood and other potentially infectious materials.” The BBP standard requires that the laboratory employer have a written exposure control plan.

In addition to blood and blood products, the BBP standard includes “other potentially infectious materials” (OPIM). Urine is the only fluid not specifically included in the BBP standard. However, because blood and blood elements frequently are associated with urine, it must be included and considered as a possible source of exposure.

Washing or sanitizing the hands is the most effective means of preventing infection. It is the single most effective way of preventing the spread of all infections. Proper hand sanitation protects you, your patient, and your co-workers, because it removes organisms. In the laboratory area, it is absolutely essential to cleanse your hands in the following situations:
- When you enter and before leaving the area
- Before and after every patient procedure
- After contact with body fluid, even if gloves were worn
- Before and after eating
- Before and after using the restroom

Every laboratory should have a safety manual that covers all safety practices and precautions. The manual should clearly explain procedures to be followed in the event of an accident. A section of the manual should prominently list emergency numbers for ambulance, fire, police, and other security services, as well as
evacuation plans. Emergency numbers also should be posted near the telephone, and plans for evacuation must be posted. Second, the manual should give instructions for reporting and documenting accidents and should have an accident log for recording the names and persons involved, the type of accident, and the date it occurred. Copies of this incident report form should be in the manual, along with an example of a properly completed form. It is important to note that such a form documents not only the accident, but also the steps taken to prevent the recurrence of such an accident.

### SAFETY GUIDELINES FOR OTHER POTENTIALLY INFECTIOUS MATERIALS

- Handle and process all specimens as if they contain infectious material.
- Wipe the outside of specimen containers with a germicide.
- Dispose of all infectious materials according to state and federal guidelines.
- Clean up spills using a disinfectant (see Chapter 27).
- Immediately dispose of any chipped or broken glassware in a special disposable container.

### SPECIMEN COLLECTION, PROCESSING, AND STORAGE

#### Laboratory Requisitions and Reports

A patient’s medical record should be maintained in an organized manner to promote easy access to the desired information. Various methods are used to file laboratory reports in a patient’s medical record. Many offices compile records in a set order so that the laboratory report sheets follow entry A and precede entry B. Another method is to use standard-sized sheets of a specific color and stagger the reports from the bottom of the sheet upward.

As discussed in Chapter 28, in the source-oriented medical record, all like reports are filed in one section. For example, all laboratory reports are together, all surgical reports are together, and all electrocardiograph reports are together. The latest test is placed on the top, because it is the most important for the patient’s current care and treatment. In the problem-oriented medical record, all test results are entered and recorded in the objective part of the progress notes, preceded by the number and title of the particular problem.

The medical assistant’s responsibility is to make sure all reports are received for diagnostic tests performed on the patient outside the physician’s office. Only after the physician reviews the test results should they be filed in the patient’s record.

When the physician requests laboratory testing that must be done outside of the office, a written requisition for the work must be sent to the laboratory with the patient or with the specimen (Figure 51-4). These forms are preprinted, and the most commonly requested tests are indicated in logical sequence. Patient information must be complete, accurate, and legible.

#### Specimen Collection

The medical assistant is responsible for the collection of many different types of specimens. It is important to recognize that all clinical laboratory results are only as good as the specimen received. The importance of specimen collection cannot be overemphasized. If the test results are to be accurate indicators of the patient’s state of health, it is imperative that the concepts of specimen collection be understood and followed exactly. The most common specimens are blood, urine, and swab samples collected from wounds or mucous membranes. Less often, feces, gastric contents, CSF, tissue samples, semen, and aspirates, such as synovial fluid, are submitted for testing. These specimens are analyzed for levels of many chemicals and drugs, types and numbers of cells present, and the presence of microorganisms.

Initial identification of the patient is essential, as is collection of the specimen in an appropriate collection container. For example, blood may be collected using a vacuum tube system. These tubes are available in a variety of sizes, with and without preservatives and anticoagulants. The tubes are color coded so that the color of the stopper denotes which, if any, additive is present (Figure 51-5). Collection in an incorrect tube results in an unacceptable specimen, and recollection is necessary. If the specimen is to be tested for the presence of microorganisms, a sterile container must be used. If the patient is to collect the specimen at home, he or she should be provided with the appropriate container and complete instructions for collection. Bear in mind the principles of patient education, as discussed in Chapter 29, and be sensitive to individual patient factors, which sometimes can affect the patient’s understanding of the instructions, as well as the person’s ability to follow through on those instructions.

The medical assistant should always check the laboratory’s specimen requirements manual for any unfamiliar tests. The manual lists all information on specimen collection. Any unanswered questions should be resolved by calling the laboratory before collecting the specimen. The container must be labeled properly at the time of collection; unlabeled containers will not be accepted for laboratory testing. Labels should include the patient’s full name, the date and time of collection, and the type of specimen. Label information typically required when specimens are sent to a reference laboratory includes:

- Physician’s name, account number, address, and phone number
FIGURE 51-4 Laboratory requisition form.

- Patient's full name, surname first; age, date of birth, and gender; address and insurance information
- Source of specimen
- Date and time of collection
- Specific test (or tests) requested

- Medications the patient is taking
- Possible diagnosis
- Indication of whether test is to be performed STAT

If the specimen is to be mailed, it must be carefully packaged to prevent breakage, damage, or contamination by all persons handling it. Place specimens in unbreakable tubes with safe-top lids and wrap the containers in absorbent material. Tape lids shut so that no leakage occurs if the specimen container breaks. Place all specimens in a second container, such as an impervious bag, for transport. The completed requisition goes inside the outermost wrap. Usually Styrofoam mailers (Figure 51-6) are used, because they cushion the sample and also provide insulation. Styrofoam inserts can be shaped to fit around the specimen container. A warning label specifying the etiologic agent or biologic specimen is placed on the outside of the container. Most offices have a laboratory courier service that picks up specimens periodically throughout the day. Specimens should be properly stored (some require refrigeration) until the courier arrives. Instructions for properly obtaining, processing, and preparing a specimen for transport usually are supplied by the testing laboratory. If the instructions are not clear or if you have a question
about a particular collection, the laboratory can answer your question over the phone. Criteria for safe shipping of specimens include the length of time that is acceptable for transit, the recommended temperature ranges to maintain the integrity of the specimen, and whether light can affect the specimen.

### Preventing Contamination

Medical assistants must take care to prevent contamination of the specimen and themselves. Expiration dates on swabs, tubes, transport media, and other collection containers should be checked before these items are used. An improperly handled specimen may become contaminated or may contaminate the surrounding environment. Standard Precautions should be followed. All blood and other body fluids from all patients should be considered infectious.

Sufficient samples should be collected for the tests requested by the physician. Amounts may vary based on the methods used. A report returned from the laboratory marked "QNS" (quantity not sufficient) indicates a request for an additional specimen. Make sure to clarify any questions about the previous specimen by calling the laboratory before collecting a new one.

The specimen collected must be a true representative sample. A swab for a wound culture collected from the surface of the wound generally does not yield the same results as one taken from the depths of the wound. A hemolyzed blood specimen or one taken from an atypical area, such as a hematoma or the area above or below an intravenous drip, shows marked differences in many tests. If a large volume of specimen is collected, such as a 24-hour urine specimen, the total volume or weight must be carefully measured and recorded. The specimen must be well mixed before an aliquot is removed and submitted for testing.

### Proper Handling, Processing, and Storage

The specimen must be handled, processed, and stored according to individual guidelines to avoid causing any alterations that would affect test results. The medical assistant should determine whether the specimen needs to be kept warm or cool. Specimens such as urine require chilling if testing will not be performed immediately. Some cultures or specimens need to be kept at body temperature after collection. Samples for gonorrhea cultures and semen analysis are two such examples, because cooling kills the microorganisms and sperm. When required, serum must be separated from the cells as soon as possible after the specimen has clotted to prevent changes caused by the metabolism of the cells. Specimens for bilirubin testing must be protected from light. Some specimens need to be frozen to prevent chemical constituents from changing. Laboratory specimen requirements should be consulted to ensure that each specimen is handled and processed properly.

### Chain of Custody

When a specimen may be needed as evidence in a court case, certain procedures must be followed for collecting and handling the specimen. Forensic or medicolegal implications require that any results of the testing of a specimen be obtained in such a fashion that they are recognized by a court of law. Specimen processing must be documented meticulously, ensuring that no tampering with the evidence has occurred. Chain of custody refers to the stepwise method used to collect, process, and test a specimen. The documentation must be signed by every person who has contact with the specimen, from collection to final reporting of results. Blood alcohol level testing and drug screening often require chain of custody handling. Everything needed for collection of the specimen is provided in a kit—even the gloves, the vacuum tube, and the needle to collect the blood specimen. Documentation is included and must be signed by all personnel. Medical assistants and phlebotomists have been subpoenaed to testify in court about specimens they have collected; therefore, it is in your best interest to follow chain of custody procedures rigorously.

### Collecting Specimens for Laboratory Tests and Informing the Patient of the Results

1. The healthcare practitioner orders laboratory tests based on the physical examination findings and/or to diagnose a disorder.
2. Complete a lab requisition.
3. Collect the specimen after receiving the physician’s order or instruct the patient on how to collect the ordered specimen at home.
4. Label the appropriate container.
5. Process the specimen as trained or prepare the specimen for transport to a reference laboratory.
6. Properly dispose of specimens collected and tested in the office in biohazard waste containers after tests are completed.
7. The laboratory report shows the results of the test. Reference lab results are filed in the patient’s medical record after the physician has reviewed and signed them. The results of tests performed in the office are recorded in the patient’s record.
8. Confidentially notify the patient of test results according to office policy and document in the patient’s record that test results were received.
CHAPTER 51  Assisting in the Clinical Laboratory

QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance Guidelines

Quality assurance (QA) is the pledge of healthcare professionals to work to achieve the highest degree of excellence in the healthcare given every patient. QA encompasses a comprehensive set of policies and procedures developed to ensure the reliability of laboratory testing. It includes quality control (QC), personnel orientation, laboratory documentation, knowledge of laboratory instrumentation, and enrollment in a proficiency testing program. QA focuses on establishing a series of operating procedures to produce reliable laboratory results for the benefit of the patient, the physician, and the medical assistant who does the laboratory testing.

These policies benefit the physician by reducing the liability for inaccurate reporting of test results. When a physician uses a laboratory test in diagnosing, the results must be compared with reference values. Reference values also are useful for assessing the efficacy of a patient's course of treatment. The QA system enables the laboratory to assess, verify, and document the quality of the test results. This documentation is a way of comparing “what is” with “what should be.” QC is covered in Subpart K of the February 28, 1992, CLIA regulations published in the Federal Register. POLs are required to have a procedure manual that describes the processes for testing and reporting patients' results. Personnel are required to calibrate laboratory instruments and verify the calibrations at least every 6 months. In addition, they must run two levels of control material each day of testing and document the results, and they must perform and document remedial action when errors or problems are identified. Finally, preventive maintenance schedules must be followed and documented.

CRITICAL THINKING APPLICATION 51-3

As part of her daily routine, Marsha performs quality control on the lab’s glucometer before patient testing. According to the package insert, the value of the control sample should be 160 mg/dL ± 3 mg/dL. Marsha performs the test, and the glucometer reads 140 mg/dL. She repeats the test three times, obtaining values of 141, 140, and 139 mg/dL. Is the instrument accurate? Is the instrument reliable? Can she proceed with the day's testing? If not, what should she do?

GUIDELINES FOR A PREVENTIVE MAINTENANCE PROGRAM

- Follow the manufacturer’s instructions for calibrating instruments.
- Read and understand the instructions for routine instrument care.
- Perform all preventive maintenance specified by the manufacturer's instructions.
- Keep spare parts available for immediate use.
- Record the name, address, and phone number of a contact person for maintenance or repair.
- Create a maintenance form or use the one provided.

QUALITY-CONTROL GUIDELINES

The objective of QC in the laboratory is to ensure the accuracy and reliability of test results while detecting and eliminating error. Accuracy refers to how close the obtained value is to the real, true value, and reliability refers to the reproducibility of the test procedure. POLs play a vital role in QC, because patient treatment often is based on or reinforced by the results of laboratory tests. Mandated by law, QC programs monitor all aspects of laboratory activity, from specimen collection through the processing, testing, and reporting steps. Programs check supplies, reagents, machinery, personnel, and actual test performance. Without a QC program, laboratory error is difficult to detect unless the physician notices test results inconsistent with a patient's history. Undetected laboratory errors may result in harm to the patient.

Specially prepared QC samples are tested daily, along with patient samples. The results of testing performed on the QC samples must be within a pre-established range before the patient results can be reported. The QC samples, called controls, usually are supplied with prepackaged kits intended for use in the small laboratory. The controls should be analyzed at specified intervals. For example, positive and negative controls supplied with pregnancy test kits should be performed with each patient specimen. Urinalysis dipsticks (used for chemical examination of urine) should be checked daily and each time a new container is opened. Controls for automated chemistry analyses should be performed at specified intervals during the day. Consistent results of controls ensure constant conditions throughout the testing sequence.

Standardization of laboratory instruments is important to ensure proper operation and accurate test results. Standardization involves testing samples with specific, known values and adjusting the instrumentation until it displays that value. These samples are known as standards. Preventive maintenance prolongs the life of equipment and reduces breakdowns; it includes daily cleaning and adjustment and replacement of parts when necessary. Each instrument should have a log or worksheet for recording all changes, including daily maintenance.

Accurate record keeping is one of the key responsibilities of a medical assistant. Various forms are available to assist the recording of laboratory information, although much of this information now can be found online and recorded in an electronic format. If your office uses hard copies, the primary record is the laboratory master logbook, in which each procedure performed in the POL is entered with the dates clearly shown. Every day that patient tests are performed, QC tests must also be performed. The results of standardization tests and the dates when new control vials are begun must be entered, along with the expiration dates of the controls. The records must be retained for several years, the exact number determined by state law and CLIA mandates.

CRITICAL THINKING APPLICATION 51-4

Marsh is performing a blood urea nitrogen (BUN) test on a sample using an automated BUN analyzer. First she performed QC by using a test sample and made adjustments to the equipment as needed. Then she tested the patient's sample and recorded the value. Explain why she ran the control sample and why the patient sample was the last to be tested.
<table>
<thead>
<tr>
<th>Table 51-3 Greenwich and Military Times</th>
<th>Table 51-4 Common Laboratory Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GREENWICH TIME</strong></td>
<td><strong>MILITARY TIME</strong></td>
</tr>
<tr>
<td>1:00 AM</td>
<td>0100 hours</td>
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<tr>
<td>3:00 AM</td>
<td>0300 hours</td>
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<td>11:00 PM</td>
<td>2300 hours</td>
</tr>
</tbody>
</table>

**Laboratory Mathematics and Measurement**

All laboratory testing, from specimen collection through reporting of results, relies on accurate use of values and measurements. For example, values are used for reporting the time the sample was collected, the amount of analyte found in a specimen, the volume of the specimen, and dilutions used in sample preparation and for recording QC results.

**Measuring Time**

Time of day often is a critical factor in patient care. Medications must be administered, diets must be followed, and specimens must be collected on a particular schedule. Many clinical laboratories use the 24-hour clock when recording time; this method avoids the confusion that comes with the Greenwich clock, which uses the AM (morning) or PM (afternoon) designations.

The 24-hour clock system, also known as military time, is expressed with four digits in terms of “hundred hours.” Noon is referred to as 1200 (“twelve hundred”) hours; midnight is 0000 (“zero hundred”) hours. The military clock is based on a 60-minute hour, just as is the Greenwich clock; therefore, 5:35 PM is expressed as 1735 (“seventeen thirty-five”) hours (Table 51-3).

**Measuring Temperature**

Two scales currently are used for measuring temperature (Table 51-4); each is divided into units called degrees. The Fahrenheit scale is considered part of the English system of measurement and is the scale most commonly used in the United States. The Celsius scale, formerly called the centigrade scale, is used in countries that apply the metric system. On the Celsius (C) scale, water freezes at 0°C and boils at 100°C. On the Fahrenheit (F) scale, water freezes at 32°F and boils at 212°F. The method for converting temperatures from one scale to the other is found in Chapter 31.

**Units of Measurement**

The units of measurement that we commonly use in the United States differ from those used in the clinical laboratory. In everyday life we use the English system of measurement, in which weight is measured in ounces and pounds, length is measured in inches and feet, and volume is measured in cups and quarts. In the laboratory, the metric system and the Système International (SI) are used. It is important that the medical assistant memorize and practice these systems so that he or she can communicate professionally.

The metric system is based on a decimal system, which has basic units and prefixes that indicate a system of division in multiples of ten. The basic units of the metric system are the gram (g) for weight, the meter (m) for length, and the liter (L) for volume. Prefixes are added to each symbol to reduce or enlarge them by units of ten. This information was already discussed in Chapter 34. The most common metric units used in the laboratory are millimeters (mm), centimeters (cm), micrograms (mcg), milligrams (mg), grams (g), microliters (mcL), milliliters (mL), liters (L), and cubic centimeters (cc). The cubic centimeter and milliliter are used interchangeably in the clinical laboratory.

Quantitative test results are reported using the appropriate units of measurement. Some commonly used designations for reporting analytes are mg, µg, g, and L. Blood glucose, for example, is reported in milligrams per deciliter (mg/dL); hemoglobin levels are reported as grams per deciliter (g/dL).

The Système Internationale, or SI units, is a system of reporting numbers that has been recognized by international organizations such as the World Health Organization (WHO). Many countries have adopted its use; the United States has not completely converted to the SI system.

The SI is an adaptation of the metric system that uses several of the basic units, although many are different for reporting results. For example, blood glucose is reported in millimoles per liter (mmol/L), and hemoglobin is reported in grams per liter (g/L). Therefore, it is very important that the medical assistant double-check the laboratory's standard and include the units of measurement when reporting test values.

**Measuring Liquid Volume**

Most vessels used to measure volume in the laboratory are plastic and disposable for infection control purposes. Beakers are wide, straight-sided cylindric vessels that are used for mixing or reagent
preparation. They are not calibrated to hold an exact volume but can be used for estimating volume. Erlenmeyer flasks are used for reagent preparation and have a narrower mouth than a beaker. Like beakers, they are not calibrated.

Test tubes come in many sizes and are typically disposable. Test tubes may be sterile, and some may be calibrated. Graduated cylinders are used for measuring exact amounts of a liquid. The size of the cylinder should be matched as closely as possible to the volume of liquid being measured to obtain the most accurate reading. In other words, a 50-mL graduated cylinder should not be used to measure 10 mL—a 10-mL cylinder should be used. For the most accurate measurement, a volumetric flask is used. Volumetric glassware, including flasks and pipets, must go through rigorous calibration to ensure the accuracy of the measurement. They are calibrated to single, specific amounts, such as 100 mL or 500 mL, and cannot be used to measure volumes other than those indicated. Figure 51-7 shows the glassware used in a laboratory.

Pipets (Figure 51-8) also are used extensively in the laboratory. These cylindrical, calibrated tubes are used to deliver or transfer specified volumes of liquid. Drawing liquid into the pipet requires a bulb or a vacuum pump—type device; pipetting by mouth is forbidden. For most general laboratory procedures, two main types of manual pipets are used: the volumetric pipet, which is used for transferring, and the graduated pipet, which is used for measuring. The graduated pipet is classified according to whether it contains or delivers the amount specified. A “to deliver” (TD) pipet delivers the specified volume by drawing the liquid up to the calibration mark and then allowing it to drain out vertically, unassisted. A small amount of liquid always remains in the tip of the pipet. A “to contain” (TC) pipet must be emptied completely to deliver the specified amount. When mouth pipetting was routinely practiced, these pipets were said to be “blown out,” meaning that all the liquid was to be forcibly expelled from the pipet. This is now an unacceptable practice.

A serologic pipet is much like the graduated pipet in appearance. However, the tip opening is large, which permits a fast flow of liquid but less accuracy. The pipet also is calibrated into the tip. Serologic pipets are used to prepare dilutions of serum but should not be used in the preparation of reagents.

When measuring liquid in a narrow vessel, such as a pipet or graduated cylinder, you will notice that the liquid has a curvature at the surface. This is called the meniscus, and it should be adjusted so that at eye level the bottom of the curve is at the calibration line (Figure 51-9).

Micropipettors (Figure 51-10) are used to deliver very small amounts of liquid, from 1 to 1,000 microliters (mL). It is important to follow the manufacturer’s instructions for the device, because each may be slightly different. These pipetting devices must be fitted with an appropriate disposable tip. The tips may be sterile, depending on their use. The device is fitted with a
piston at the top, which must be depressed before the pipet is filled and when the pipet is drained.

**CRITICAL THINKING APPLICATION 51-5**

Marsha is preparing a solution and is required to measure a 6 mL volume of saline solution. She has a 10 mL TD pipet. The pipetting device provided by the laboratory uses vacuum to draw up the liquid and forced air to expel it. Marsha knows that she should allow the pipet to drain with the force of gravity, yet she is required to use a pipetting device. How will she accurately deliver 6 mL?

**Preparing Dilutions**

When the medical assistant performs laboratory tests, he or she may find it necessary to dilute a body fluid sample with a diluent, such as water, saline solution, or a buffer. For example, dilutions must be made when testing for the presence and strength of antibodies in serum or when a patient's analyte level is grossly elevated and cannot be read by the instrument.

The term *dilution* refers to parts in total volume; it is a statement of relative concentration and represents expressions of concentration, not expressions of volume. For example, a 1:10 dilution can be prepared by measuring 1 mL of sample and diluting it with diluent to 10 mL. This means adding 9 mL of diluent. The same 1:10 dilution can be prepared by mixing 2 mL of sample and 18 mL of diluent or 0.5 mL of sample and 4.5 mL of diluent. Note that the final volume is not the same in each of the above examples, yet each is a 1:10 dilution. Any volume of a dilution can be made as long as the relative amounts of the components remain the same.

**CLINICAL LABORATORY EQUIPMENT**

**Microscope**

Nearly every medical laboratory is equipped with a microscope. This indispensable instrument is used to view objects too small to be seen with the naked eye (Figure 51-11). The microscope is used to evaluate stained blood smears, urine sediment, vaginal secretions, and smears made from body fluids or microbiologic cultures. Typically, there are no QC procedures for these tests (Table 51-5). Provider performed microscopy procedures (PPMP) laboratories must meet the same quality standards as a laboratory that performs moderate-complexity tests; laboratories that perform only CLIA-waived tests may perform certain microscopic tests through a certificate of waiver (COW). In a physician's office laboratory with a COW, only a physician, physician's assistant, dentist, or other highly trained personnel can perform microscopic analysis. If the laboratory is CLIA certified to perform moderate-complexity testing, personnel other than physicians can perform microscopic analysis provided that they are trained and supervised by a qualified individual and the laboratory maintains its CLIA certification.

Microscopes have three components: the magnification system, the illumination system, and the framework, which includes all components responsible for positioning the slide and focusing. The magnification system includes the ocular and the objective lenses. Microscopes are either monocular or binocular. A monocular microscope has one eyepiece for viewing, and a binocular has two. The eyepiece, or ocular, is located at the top of the microscope and contains a lens to magnify what is being viewed. The usual magnification is 10 times (10X). In addition to the ocular, compound microscopes have objective lenses that increase the magnification of the specimen. The objectives are attached to the revolving nosepiece. Most microscopes have four objectives, each with a different magnifying power. The shortest objective has the lowest power (4X) and is called the scanning lens. This lens is used to scan the field of interest and then focus on a particular object. Greater detail is observed with the next longest objective, which is low power (10X). The high or high dry objective usually has a magnification of 40X or 45X, and the longest objective, oil immersion (100X), allows for the finest focusing of the object and requires the use of a special oil that is placed directly on the slide. This special oil, called immersion oil, prevents refraction of the light and improves the resolution (clarity) of the magnified image. Oil immersion is used to view cells and extremely small materials, such as bacteria and platelets, and also to examine stained specimens.

To determine the total magnification of the specimen, multiply the magnification of the objective lens by 10 (the magnification of the ocular). Therefore, if you have the 10X objective in place when you are observing blood cells, you are magnifying the image 100 times.

The arm of the microscope connects the objectives and oculars to the base, which supports the microscope and contains its light source. The stage of the microscope holds the slide to be viewed. Together, the light source, the condenser, and the iris diaphragm compose the illumination system. The condenser directs light up through the stage, and the iris diaphragm regulates the amount of light passing through the specimen. Just above the base are the focusing knobs. The coarse adjustment is used only with scanning and low-power lenses, and the fine adjustment is used with high-power and oil immersion lenses.

Microscopes are very precise and expensive instruments that require careful handling. The amount of routine mainte-
TABLE 51-5 Selected Microscopy Tests Performed by Providers

<table>
<thead>
<tr>
<th>TEST NAME</th>
<th>DESCRIPTION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct wet mount</td>
<td>Examination of specimens for presence or absence of</td>
<td>Observing vaginal secretions for presence of yeast to assist with</td>
</tr>
<tr>
<td></td>
<td>bacteria, fungi, parasites, and human cellular elements</td>
<td>diagnosis of vulvovaginal candidiasis</td>
</tr>
<tr>
<td>KOH preparation</td>
<td>Any preparation using potassium hydroxide</td>
<td>Observing skin scrapings for the presence of fungi</td>
</tr>
<tr>
<td>Fecal leukocyte examination</td>
<td>Simple stain of fecal specimen; assists in diagnosis of</td>
<td>Leukocytes are found in stool in antibiotic-associated colitis,</td>
</tr>
<tr>
<td></td>
<td>diarrhea disease</td>
<td>ulcerative colitis, shigellosis, and salmonellosis</td>
</tr>
<tr>
<td>Pinworm examination</td>
<td>Preparations are observed for the presence or absence of</td>
<td>See Procedure 55-7, Performing a Cellulose Tape Collection for</td>
</tr>
<tr>
<td></td>
<td>Enterobius vermicularis eggs</td>
<td>Pinworms</td>
</tr>
<tr>
<td>Postcoital direct, qualitative examinations</td>
<td>Vaginal or cervical mucus is examined 4-10 hr after intercourse for presence of live, motile sperm</td>
<td>Assists in the diagnosis of infertility</td>
</tr>
<tr>
<td>Qualitative semen analysis</td>
<td>Semen is examined for the presence or absence of spermatozoa; motility of the sperm is noted</td>
<td>Assists in postvasectomy semen analysis and in the diagnosis of infertility</td>
</tr>
<tr>
<td>Urine sediment examination</td>
<td>Urine sediment is examined for presence or absence of formed elements</td>
<td>Part of a routine urinalysis; see Procedure 52-6, Preparing a Urine Specimen for Microscopic Examination</td>
</tr>
</tbody>
</table>

nance required depends on the amount of daily use. Dirt is the enemy of the microscope, which must be kept scrupulously clean at all times. Oil, makeup, dust, and eye secretions all can obstruct vision through the lens and may transmit infective organisms. The microscope should always be stored in a plastic dust cover when not in use. Lenses should be cleaned before and after each use with lens paper and lens cleaner. Any other type of tissue scratches the lenses or leaves lint residue behind. Routine use of solvent cleaners, such as xylene, is not recommended, because these cleaners may loosen lenses. However, xylene can be used to remove oil that has dried on the lenses. The body of the microscope should be dusted with a soft cloth.

The microscope should be placed in a permanent location in the laboratory on a sturdy table in an area where it cannot be bumped. If a microscope must be moved, it should be carried securely, with one hand supporting the base and the other holding the arm. When the microscope is stored, it should be left covered and with the low-power objective in the lowest position. The stage should be centered.

Using a microscope involves focusing and illumination (Procedure 51-1). The image is focused by moving the objective
PROCEDURE 51-1

Use the Microscope

GOAL: To focus the microscope properly using a prepared slide under low power, high power, and oil immersion.

EQUIPMENT and SUPPLIES

- Microscope
- Lens cleaner
- Lens tissue
- Slide containing specimen

PROCEDURAL STEPS

1. Sanitize your hands.
2. Gather the needed materials.
3. Clean the lenses with lens tissue and lens cleaner.
   **PURPOSE:** Dust on lenses can obscure elements in the microscopic field.
4. Adjust the seating to a comfortable height.
5. Plug the microscope into an electrical outlet and turn on the light switch.
6. Place the slide specimen on the stage and secure it.
7. Turn the revolving nosepiece to engage the 4× or 10× lens.
   **PURPOSE:** Always begin microscopic observations at low power.
8. Carefully raise the stage while observing with the naked eye from the side.
9. Focus the specimen using the coarse adjustment knob.
   **PURPOSE:** The coarse adjustment knob quickly brings the specimen into focus.
10. Adjust the amount of light by closing the iris diaphragm or adjusting the light from the source.
    **PURPOSE:** Too much light when using the low-power objective can be irritating to the microscope's eyes.
11. Switch to the 40× lens. Use the fine adjustment knob to focus the specimen in detail.
12. Turn the revolving nosepiece to the area between the high-power objective and oil immersion.
13. Place a small drop of oil on the slide.
    **PURPOSE:** Immersion oil has nearly the same refractive index as glass and prevents refraction of the light, thus improving resolution.
14. Carefully rotate the oil immersion objective into place. The objective will be immersed in the oil.
15. Adjust the focus with the fine adjustment knob.
    **PURPOSE:** The fine adjustment knob moves the objective slowly, preventing damage to the microscope and the slide.
16. Increase the light by opening the iris diaphragm and raising the condenser.
    **PURPOSE:** Lighting is crucial to microscopy; the higher the magnification, the more light that is needed.
17. Identify the specimen.
18. Return to low power but do not drag the 40× lens through the oil.
19. Remove the slide and dispose of it in a biohazard container.
20. Lower the stage.
21. Center the stage.
    **PURPOSE:** Returning the microscope to this position protects it during storage.
22. Switch off the light and unplug the microscope.
23. Clean the lenses with lens tissue and remove oil with lens cleaner.
    **PURPOSE:** Dust and oil must be removed from the lenses after a procedure.
24. Wipe the microscope with a cloth.
25. Cover the microscope.
26. Sanitize the work area.
27. Sanitize your hands.

Centrifuge

Centrifugation, which is used when solids must be separated from liquids, involves the application of increased gravitational force achieved by rapid spinning. Centrifugation is used to separate blood cells from serum and also solid materials, such as cells and crystals, from urine; it is used in many areas of the clinical laboratory.

Centrifuges (Figure 51-12) are designed for specific uses. They may be bench-top or floor models; some may be refrigerated. Some may have rotors or heads that are interchangeable. A typical clinical centrifuge may have a rotor that is set at a fixed angle, in which the specimen cups are held in a rigid position at a fixed angle; one that has a horizontal head with swinging buckets that swing out horizontally during centrifugation; and a third that is used for centrifuging capillary tubes for microhematocrit determination (see Chapter 53). Centrifuges also may be equipped with timers to automatically stop centrifugation at a set time.
Directions for using a centrifuge usually are given in terms of revolutions per minute (rpm). Spinning generates centrifugal force. General laboratory centrifuges operate at up to 6,000 rpm, generating a relative centrifugal force of up to 7,300 times the force of gravity (G). Conventional horizontal centrifuges attain speeds of up to 3,000 rpm; angle-head centrifuges can attain higher speeds (up to 7,000 rpm).

Centrifuges can be dangerous if not used correctly. The most important rule is to ensure that the centrifuge is balanced so that tubes of equal size and containing equal volume are directly across from one another in the rotor holders. Therefore, there will always be an even number of tubes in the centrifuge. If a second specimen of the same volume in the same-sized tube is not available for balance, a tube of water may be used to balance the load. Tubes being centrifuged should also be capped to prevent emission of aerosols. Rubber cups should be placed in the bottom of the carrier cups to prevent breakage of glass tubes.

Centrifuges should never be opened while they are in operation, nor should you attempt to slow a centrifuge with your hands. Most models are equipped with a brake, which should be used only in an emergency, the most common of which is a broken glass tube. In this case, wait until the centrifuge comes to a complete stop and follow the manufacturer’s instructions for disinfecting the unit; also follow Standard Precautions to prevent injury and disease transmission.

Centrifuges should be checked, cleaned, and lubricated regularly to ensure proper operation. A certified technician must use a photoelectric device or a stroboscopic tachometer to ensure the centrifuge’s speed to comply with quality assurance guidelines set forth by the CAP.

**Incubator**

Incubators are cabinets that maintain constant temperatures (Figure 51-13). Generally used in the microbiology laboratory, they maintain a constant temperature of 95° to 98.6° F (35° to 37° C), although other temperatures may also be appropriate.

Some incubator interiors may be enriched with carbon dioxide (CO₂) gas to enhance the growth of pathogenic bacteria; a pressurized tank of CO₂ gas is attached to the cabinet, and the concentration is maintained at 10%. Incubators may have warning alarms that sound if the temperature exceeds or falls below a specified range. The temperature should be checked daily, and the cabinets should be cleaned regularly with a disinfectant approved by the manufacturer.

**Autoclave**

The autoclave is an instrument that uses steam under pressure to sterilize materials that can withstand high temperatures. The principles of operation are explained in Chapter 57.

It is essential that strict QA methods be followed when an autoclave is used. A certified technician should regularly examine the autoclave, and biologic and chemical indicators should be checked daily. Biologic indicators include spore preparations that are wrapped in the autoclave load. At the end of the sterilization period, they are incubated and checked for germination. If spores fail to germinate, the autoclave reached the appropriate temperature.

**Closing Comments**

**Patient Education**

For many testing procedures, patients must be given a specific set of instructions to follow. For example, patients may be required to fast 8 to 12 hours before the collection of blood and urine samples. They may need to follow a high-carbohydrate diet for several days before a glucose tolerance test. The consumption of some foods and medication must be discontinued. The physician discusses medication alternatives with the patient. In some cases discontinuing the medication may not be medically
advisable, and this must be noted on the laboratory requisition. The laboratory then is alerted to the possibility of drug interference, and an alternative test method may be used.

Often the medical assistant is responsible for explaining to the patient the measures to be taken before laboratory testing. Make sure you have interpreted the physician's orders correctly before explaining the procedure to the patient. The patient should be given written instructions, with a phone number included on the instruction sheet so that the patient can call if he or she has questions.

### Legal and Ethical Issues

If disease did not exist, there would be little need for clinical laboratories. The fact that the human body is susceptible to disease necessitates the existence of laboratory testing. All health and safety risks cannot be anticipated or eliminated, but the risks are greatly reduced when everyone who works in the laboratory is conscious of safety guidelines. Use common sense and document everything. If you are in doubt about the safety of a procedure, ask your supervisor. If you are aware of a potential safety problem, report it to the person in charge. Your welfare, the welfare of the patient, and the welfare of your co-workers may depend on your commitment to safety.

Before the patient receives test results, the medical assistant must make sure the physician has reviewed and signed the results and has given permission for the patient to be told the results of testing. Most physicians personally inform patients of laboratory results, but some physicians may delegate this duty to office staff. Regardless of who informs the patient of test results, the individual must make sure the specific guidelines for communication are followed as stipulated in the patient's Health Insurance Portability and Accountability Act (HIPAA) release form. Maintaining a patient's privacy and confidentiality are crucial factors that must be considered when communicating with the patient about test results.

### SUMMARY OF SCENARIO

Marsha's experience in clinical laboratory testing has made her a valuable asset to her new employer. A thorough understanding of government rules and regulations, including specifics about CLIA, and the guidelines published by the CDC, EPA, and OSHA helped Marsha implement laboratory testing in the clinic. Marsha helped the physicians design a safe, efficient laboratory space with a refrigerator, centrifuge, and biohazard waste station. She developed a rigorous QA program and is now training other medical assistants to perform CLIA-waived testing.

Marsha found it most challenging to determine how to comply with proper medical waste disposal regulations. She had to make several phone calls to state environmental protection agencies, but her diligence was rewarded when the laboratory received certification. Marsha pays close attention to CLIA regulations and receives regular updates on the tests that can be performed in a POL. She currently is determining the feasibility of performing drug screenings for local businesses. Her employers are pleased with her efforts, and the patients appreciate the convenience of on-site testing.

### SUMMARY OF LEARNING OBJECTIVES

1. Define, spell, and pronounce the terms listed in the vocabulary. Spelling and pronouncing medical terms correctly bolster the medical assistant's credibility. Knowing the definitions of these terms promotes confidence in communication with patients and co-workers.

2. Apply critical thinking skills in performing patient assessment and patient care. Completing the Critical Thinking Application exercises throughout the chapter can help the student medical assistant become more adept at critical analysis of real-life situations.

3. Discuss the role of the clinical laboratory in patient care and the medical assistant's role in coordinating laboratory tests and results. The clinical laboratory is responsible for analyzing blood and body fluids and providing the physician with test results that become part of the essential data needed to diagnose and manage a patient's condition. Medical assistants are responsible for collecting specimens, instructing patients, and performing CLIA-waived and some moderately complex testing.

4. Describe the divisions of the clinical laboratory and give an example of a test performed in each division. Most physicians' offices that perform laboratory testing do so in the areas of urinalysis, hematology, chemistry, and microbiology. Routine urinalysis, complete blood counts, and throat cultures are some of the tests that might be performed in a POL.

5. Describe the Clinical Laboratory Improvement Amendments (CLIA) and how they influence laboratory testing. CLIA established the standards of quality for laboratory testing. Medical assistants can perform all CLIA-waived and some CLIA moderate-complexity laboratory procedures. Table 51-2 summarizes CLIA-waived tests.

6. Explain the three CLIA regulatory categories. A CLIA-waived test is one that is approved by the FDA for over-the-counter sales or one that has been determined to pose no unreasonable risk or harm if performed incorrectly. Other levels of tests require more training or education to perform and can be performed only in CLIA-certified laboratories.

7. Compare and contrast the agencies that govern or influence practice in the clinical laboratory, including the Centers for Disease Control and Prevention (CDC), the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the Clinical and Laboratory Standards Institute (CLSI), and the College of American Pathologists (CAP). Federal agencies that regulate the laboratory include the U.S. Department of Labor, the U.S. Department of Health and Human Services, and
the EPA. Professional agencies that provide guidelines include CLSI and CAP. Although all the agencies provide recommendations for operational procedures in the clinical laboratory, not all have the power to enforce. The Department of Labor and the EPA can impose significant fines for failing to follow regulations, but the Standard Precautions set forth by the CDC are recommended but not enforceable.

8. Summarize techniques to minimize physical, chemical, and biologic risks in the clinical laboratory.
Risks can be minimized in all areas of the laboratory by using common sense and by having a formal safety training program and an up-to-date safety manual. Safety equipment such as fire blankets, fire extinguishers, and eye wash stations should be accessible to employees. Chemicals should be clearly marked with the National Fire Protection Association (NFPA) diamond, and MSDSs should be bound in an accessible manual. Standards for Precautions should be observed when any biologic material is handled.

9. Describe the essential elements of a laboratory requisition.
The laboratory requisition must include all information needed to identify the patient, the ordering physician, the test ordered, and the specific details of collection of the specimen (e.g., time and source).

10. Display sensitivity to patients’ rights and feelings in collecting specimens.
Initial identification of the patient is essential. If the specimen to collect is not the patient’s or should be provided with the appropriate container and complete instructions for collection. Bear in mind the principles of patient education and be sensitive to individual patient factors that can affect the individual’s understanding of the instructions for specimen collection and the person’s ability to follow through on those instructions.

11. Explain chain of custody and illustrate why it is important.
Chain of custody is a method used to ensure that a specimen provided by a patient who may be involved in a legal matter is handled in a fashion that does not compromise the test results. All individuals who handle or test the specimen must be identified in writing and provide a signature.

12. Compare and contrast quality assurance and quality control.
Quality assurance involves procedures undertaken to ensure that each patient is provided excellent care. QC, which ensures that laboratory testing is accurate and reliable, is part of a QA program.

13. Describe the differences between Greenwich time and military time.
Greenwich time uses the designations AM and PM, whereas military time uses the 24-hour clock: 3:15 PM is equivalent to 1515 hours. Table 51-3 compares Greenwich and military time.

14. Identify the Fahrenheit temperature and Celsius temperature of common pieces of laboratory equipment.
Although the Celsius (Centigrade) thermometer is used in the clinical laboratory, in everyday life we commonly use the Fahrenheit system. The incubator is usually set 37°C (98°F), the autoclave sterilizes at 121°C (254°F), and the refrigerator temperature is 2°C to 8°C (35°F to 46°F) (see Table 51-4).

15. Name the metric units used for measuring liquid volume, distance, and mass.
Liquid volume is measured in liters, distance is measured in meters, and mass is measured in grams. Prefixes commonly used in the clinical laboratory include milli-(0.001), centi-(0.01), micro-(0.000001), deci-(0.1), and kilo-(1000).

16. Describe the proper use of pipets.
Pipets must be chosen according to the job they are to perform. A pipetting device, such as a bulb or pump, should be attached, and particular attention must be given to emptying the pipet. The mouth should never be used in pipetting.

17. Explain how dilutions are prepared.
Dilutions are prepared by mixing volumes of sample, such as blood, body fluids, or reagents, and volumes of diluent, such as water, saline solution, or buffer. The term dilution refers to parts in total volume and is an expression of concentration.

18. Name the parts of a microscope, and describe their functions.
The parts of the microscope can be divided into the illumination system (light source, condenser, and iris diaphragm lever), the frame (base, adjustment knobs, arm, stage, stage control), and the magnification system (objective lenses on the revolving nosepiece, oculars). The illumination system controls the light that passes through the specimen to the eye, the frame provides the structure for the instrument and the components that allow for the adjustment of the sample, and the magnification system provides the ground glass lenses that magnify the specimen.

19. Summarize selected microscopy tests that can be performed in the ambulatory care setting.
Refer to Table 51-5.

20. Demonstrate the proper use of the microscope.
Procedure 51-1 outlines the steps for using a microscope.

21. Describe the safe use of a centrifuge.
For safe use of a centrifuge, the proper tube must be used and it must be protected from breakage. Centrifuge loads must be carefully balanced. Specimens must be capped to prevent aerosols. Under no circumstances should centrifuges be opened while they are in operation.

**CONNECTIONS**

📚 **Study Guide Connection**: Go to the Chapter 51 Study Guide. Read and complete the activities.

🔗 **Evolve Connection**: Go to the Chapter 51 link at evolve.elsevier.com/kinn to complete the Chapter Review and Chapter Quiz. Peruse other resources listed for this chapter to increase your knowledge of Assisting in the Clinical Laboratory.