ASSISTING IN THE ANALYSIS OF URINE

SCENARIO

As part of her duties as a CMA (AAMA), Rosa Gonzales performs tests on patients’ urine ordered by her employer, Dr. Ronald Hill. Rosa knows that urinalysis is a very important part of patient care, and a number of urinary tests are performed in the laboratory in Dr. Hill’s busy practice. Dr. Hill most commonly orders routine urinalysis testing, but Rosa also performs some specialized tests. Today, Dr. Hill has ordered a urinalysis (UA) on a specimen from Mr. Parks, a UA and pregnancy test on a specimen from Mrs. Carpenter, and a UA and culture and sensitivity (C&S) on a specimen from Ms. Hillman.

While studying this chapter, think about the following questions:

• What is involved in a routine urinalysis?
• What quality assurance measures will Rosa take when performing laboratory tests on urine?
• How are pregnancy and drug tests performed on urine?
• How will Rosa instruct patients in the collection of urine for a routine urinalysis, a urine culture, and other specialized tests such as pregnancy tests and drug tests?

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. Understand the purpose of routine urinalysis.
4. Describe the physiology of urine formation.
5. Explain the various means and methods used to collect urine specimens.
6. Display sensitivity to patients' rights and feelings when collecting specimens.
7. Instruct a patient in the collection of a 24-hour urine specimen.
8. Instruct a patient in the collection of a clean-catch midstream urine specimen.
9. Describe the components of the physical and chemical examination of urine.
10. Measure the urine specific gravity.
11. Perform a complete urinalysis using a chemical reagent strip.
12. Recognize and correctly identify the formed elements found in a microscopic examination of urine sediment.
13. Prepare a urine specimen for microscopic examination.
14. Perform quality control measures to determine the reliability of chemical reagent strips.
15. Conduct glucose testing using the Clinitest method.
16. Explain the principle of lateral flow technology in pregnancy testing.
17. Perform a pregnancy test.
18. Describe methods for determining fertility and menopause using Clinical Laboratory Improvement Amendments (CLIA)-waived urine tests.
19. Explain the principle of lateral flow technology in drug testing on urine.
20. Demonstrate a method of drug testing on a urine specimen.
21. List means by which urine could be adulterated before drug testing.
22. Demonstrate a method of detecting adulterating substances in a urine sample for drug testing.
VOCABULARY

amorphous (a-mohr'-fuhs) Lacking a defined shape.
bilirubinuria (bi-li-roo'-bin-yoo-uh-e-uh) The presence of bilirubin in the urine.
colonforming units (CFU) A term used when reporting bacterial; one CFU represents one bacterium present in the urine sample.
crenate Forming notches or leaflike, scalloped edges on an object.
culture and sensitivity (C&S) A procedure performed in the microbiology laboratory in which a specimen is cultured on artificial media to detect bacterial or fungal growth, followed by appropriate screening for antibiotic sensitivity.
cystoscopy Visual examination of the urinary bladder using a fiberoptic instrument.
enzymatic reaction A chemical reaction controlled by an enzyme.
filtrate The fluid that remains after a liquid is passed through a membranous filter.
gold standard The paragon of excellence; the diagnostic test to which all others are compared.

A routine urinalysis (UA) is one of the more common laboratory examinations used in the diagnosis and treatment of disease. It is easily and quickly performed, and invasive techniques generally are not needed to collect the specimen. The results of a routine UA can reveal diseases of the bladder or kidneys; systemic metabolic or endocrine disorders, such as diabetes; and diseases of the liver, such as hepatitis or cirrhosis, or obstruction of the bile ducts. UA is routinely performed on all patients undergoing physical examinations and on those entering the hospital for treatment.

PHYSIOLOGY OF URINE FORMATION

For centuries abnormalities in the urine have been recognized as possible indicators of a disruption of homeostasis. One of the earliest known tests of urine was to pour it on the ground and see whether it attracted insects. Such attraction indicated "honey urine," which was known to be excreted by people with skin eruptions. Today, urine is still checked for sugar as a means of detecting diabetes.

Historically, examination of the urine became a game for quacks and charlatans. Paintings from the Middle Ages show physicians peering into round-bottomed flasks of urine, claiming not only to be able to diagnose disease, but also to see into the future by simply looking at the fluid. These charlatans became known as "pisse prophets." During the twentieth century, UA became a practical laboratory procedure, and today urine is the most commonly analyzed body fluid in the clinical laboratory.

Urine is analyzed for two reasons. The first is to detect extrinsic conditions, in which the kidney functions normally but abnormal end-products of metabolism are excreted as a result of an imbalance in homeostasis. The second is to detect intrinsic pathologic conditions that involve the kidneys or urinary tract themselves.

Anatomy of the Urinary Tract

Medical assistants must have a basic knowledge of kidney structure and urine formation to understand the results of a UA. The urinary tract consists of two kidneys, two ureters, one bladder, and one urethra. The functional unit of the kidney is the nephron. Each kidney has more than 1 million nephrons, and each nephron is composed of five distinct areas, each playing a role in urine formation (Figure 52-1). Each nephron consists of a glomerulus, which acts in filtering, and a tubule, through which the filtrate passes. As the filtrate passes through, various changes occur. Certain solutes are reabsorbed, and others are secreted into the kidney for eventual excretion. Nearly all of the water that passes through the glomeruli is reabsorbed.

The glomerulus is composed of a network of capillaries surrounded by a membrane called Bowman's capsule. The afferent arteriole carries blood from the renal artery into the glomerulus, where it then divides to form a capillary network. Where they reunite, the capillaries form the efferent arteriole, through which blood exits the glomerulus.

The tubular portion of the nephron is composed of the proximal convoluted tubule, the thin-walled segment, and the distal convoluted tubule. The thin-walled descending portion forms a loop known as the loop of Henle. Filtrate from several nephrons drains into a collecting tubule, a number of which join to form a collecting duct. The collecting ducts join to form the papillary ducts, which empty at the tips of the papillae into the calyces. The filtrate then drains into the renal pelvis and is now called urine. Urine passes from the pelvis of the kidney down the ureter and into the bladder, where it remains until it is voided through the urethra.
CHAPTER 52 Assisting in the Analysis of Urine

Formation of Urine

The kidney selectively excretes or retains substances according to the body's needs and renal thresholds. Approximately 1,200 mL of blood flow through the kidneys each minute. The blood enters the glomerulus through the afferent arteriole. The capillary walls of the glomerulus are highly permeable to water and the low-molecular-weight solutes of the plasma, and they filter through into Bowman's space and then into the tubules. Many components of the filtrate, including glucose, water, and amino acids, are partially or completely reabsorbed by the capillaries surrounding the proximal tubules. More water is absorbed, and hydrogen and potassium ions are secreted in the distal tubules. Urine is concentrated in the system of collecting tubules and the loop of Henle. The kidneys convert nearly 180,000 mL of filtered plasma per day into a final urine volume of 750 to 2000 mL, approximately 1% of the filtered plasma volume. The largest component of urine is water; the solutes are mostly urea, chloride, sodium, potassium, phosphate, sulfate, creatinine, and uric acid.

COLLECTING A URINE SPECIMEN

Patient Sensitivity

The request for a urine specimen may create an embarrassing moment for the patient. The request should be made in private, such as after the patient is seated in the examination room, and the individual should be given explicit instructions so that he or she understands what is expected. The medical assistant should use therapeutic communication to explain the details of the procedure to the patient and should be observant for indications of confusion. If a language barrier exists, be creative but respectful of the patient's need to follow through correctly on the instructions for collection of the specimen.

Containers

The most important requirement for a collection container is scrupulous cleanliness. The physician's office laboratory should provide a container; patients should not use jars from home. Disposable, nonsterile, plastic, or coated paper containers are the most common and are available in many sizes with tight-fitting lids. If the sample may be sent to the laboratory for a culture, the specimen must be collected in a sterile container. Special pliable polyethylene bags with adhesive (see Chapter 42) are used to collect urine from infants and children who are not toilet trained. For specimens that must be collected over a specified period, large, wide-mouth plastic containers with screw-cap tops are used. Most routine UA testing, pregnancy testing, and testing for abnormal analytes are performed on urine collected in non-sterile containers.

As mentioned, when a urine culture is ordered, the specimen must be collected in a sterile container. Such containers are packaged with an intact paper seal over the cap and/or in sterile envelopes (Figure 52-2). The label on all specimens must include the patient's name, the date and time of collection, and the type of specimen. Always put on gloves before handling filled specimen containers.
UNIT NINE  DIAGNOSTIC PROCEDURES

CRITICAL THINKING APPLICATION 52-1

It is 9 AM, and Rosa has received three urine specimens in the laboratory. One of the specimens is in a cup with a paper tab, indicating that the container was sterile, and the other two are in nonsterile containers. What procedures do you think might be performed on the urine collected in the sterile container? What might Rosa do with the other urine specimens? What information should she look for on the label of each specimen?

Methods of Specimen Collection

Most analyses are performed on freshly voided urine collected in clean containers; this is called a random specimen. If the specimen is ordered to be collected when the patient arises in the morning, it is called a first morning specimen. These specimens are most concentrated and are best for nitrite and protein determination, bacterial culture, pregnancy testing, and microscopic examination. Two-hour postprandial urine specimens, collected 2 hours after a meal, are used in diabetes screening and for home diabetes testing programs. The 24-hour urine specimen is collected over 24 hours to provide a quantitative chemical analysis, such as hormone levels and creatinine clearance rates (a procedure for evaluating the glomerular filtration rate of the kidneys) (Procedure 52-1).

A second-voided specimen usually is collected to determine glucose levels; the first void of the morning is discarded, and the second void of the day is collected. For a catherized specimen, the physician, physician's assistant, or nurse must insert a sterile catheter into the bladder to collect the specimen. A suprapubic specimen is collected with a needle inserted directly into the bladder.

The minimum volume for a routine UA usually is 12 mL, but 50 mL is preferred. For any type of collection, it is imperative that the patient receive adequate verbal and/or written instructions. The easiest directions for the patient are to ask the person to fill the container half way.

A clean-catch midstream specimen (CCMS) is ordered when the physician suspects a urinary tract infection and therefore orders a urine culture for examination of microorganisms. The clean-catch technique is used to remove microorganisms from the urinary meatus by thoroughly cleansing the area around the meatus and to flush out the distal portion of the urethra. Because the specimen is collected in the medical office by the patient, the medical assistant needs to give complete, understandable instructions to the patient on the method of collection (Procedure 52-2). Failure to do so may mean that the patient will have to return to the office to provide another specimen. For a urine culture, the urine is collected either by catheterization or by the clean-catch method in a sterile container.

Handling and Transportation of a Specimen

Proper handling of specimens is essential. The chemical and cellular components of urine change if the urine is allowed to stand at room temperature (Table 52-1). Urine specimens should be kept refrigerated and should be processed within 1 hour of collection. If the specimen must be transported to a referral laboratory, evacuated transport tubes are available; these contain preservatives and look much like blood collection tubes (Figure 52-3). The vacuum in the tube allows for the delivery of 7 to 8 mL of urine, using a transfer straw or a urine collection cup with an integrated sampling device. Alternately, the urine can be poured into the tube after removing the stopper. The preservatives in the BD Vacutainer cherry red/yellow-stoppered tube, chlorhexidine, ethylparaben, and sodium propionate, prevent the overgrowth of bacteria and inhibit changes in the urine that can affect test results. Chemical reagent strip testing can be performed on preserved specimens; however, it should be performed within 72 hours. Tubes may be held at room temperature during this time.

A different preservative must be used for urine specimens slated for culture. The BD Vacutainer urine collection kit contains the preservatives sodium formate and boric acid to help preserve the level of bacteria present at the time of collection. This transport system should be used only for urine specimens that will be cultured. Results on the chemical reagent strip may be altered by these preservatives. Culture and sensitivity (C&S) testing should be performed within 72 hours. Tubes may be held at room temperature.

A laboratory request form must be completed for all specimens that will be transported to another site for analysis. Typical forms include the patient's name and the date, type of urinalysis ordered, name of the physician requesting the examination, appropriate ICD-9-CM code for the diagnosis that warranted the test, and a line for the physician to sign after he or she has reviewed the results. Specimens are sent to the laboratory in a plastic biohazard bag that zips closed and has an outside pocket where the laboratory request is placed.

GUIDELINES FOR CARING FOR A URINE SPECIMEN OBTAINED AT HOME

- Do not put anything but your urine into the bottle.
- Do not pour out any liquid or powdered preservative from the container.
- If you accidentally spill some of the preservative on yourself, immediately wash with water and call the testing center or designated laboratory.
- Always keep the collection bottle cool. Refrigerate or keep the bottle in an ice-filled cooler or box.
- Keep the cap on the container.
PROCEDURE 52-1

Explain the Rationale for Performing a Procedure: Instruct a Patient in the Collection of a 24-Hour Urine Specimen

GOAL: To collect a 24-hour urine sample for creatinine clearance.

EQUIPMENT and SUPPLIES
- 3-L urine collection container
- Printed patient instructions
- Laborator/ requisition
- Patient’s medical record

PROCEDURAL STEPS

1. Greet the patient by name.
   PURPOSE: To make sure you have the right patient.

2. Label the container with the patient’s name and the current date, identify the specimen as a 24-hour urine specimen, and include your initials.
   PURPOSE: Labeling the container prevents a possible mix-up of specimens.

3. Explain the following instructions to adult patients or to the guardians of pediatric patients.

4. After explaining the following instructions, give the patient the specimen container with written instructions to confirm understanding.

Patient Instructions for Obtaining a 24-Hour Urine Specimen

1. Empty your bladder into the toilet in the morning without saving any of the specimen. Record the time you first emptied your bladder.

2. For the next 24 hours, each time you empty your bladder, the urine should be voided directly into the large specimen container (Figure 1).

3. Put the lid back on the container after each urination and store the container in the refrigerator or an ice chest throughout the 24 hours of the study.
   PURPOSE: To inhibit microbial growth in the specimen.

4. If at any time you forget to empty your bladder into the specimen container or if some urine is accidentally spilled, the test must be started all over again with an empty container and a newly recorded start time.
   PURPOSE: The test will be inaccurate if the patient fails to collect all urine produced during the designated 24-hour period.

5. The last collection of urine should be done at the same time as the first specimen on the previous day so that exactly 24 hours of urine collection is completed. The collection ends with the first voided morning specimen that completes the 24-hour collection period.

6. As soon as possible after collection is completed, return the specimen container to the physician’s office.

7. Give the patient the specimen container with written instructions to confirm understanding.


Processing a 24-Hour Urine Specimen

1. Ask the patient whether he or she collected all voided urine throughout the 24-hour period or whether any problems occurred during the collection process.
   PURPOSE: To confirm the accuracy of the specimen.

2. Complete the laboratory request form and prepare the specimen for transport.

3. Store the specimen in the refrigerator until it is picked up by the laboratory.

4. Document that the specimen was sent to the laboratory, including the type of test ordered, the date and time, and the type of specimen.

CRITICAL THINKING APPLICATION 52-2

Dr. Hill has ordered a UA on the specimen from Mr. Parks, a UA and pregnancy test on the specimen from Mrs. Carpenter, and a UA and C&S on the specimen from Ms. Hillman. After reviewing the requisitions and entering the patient information into the daily logbook, Rosa notes that Mrs. Carpenter’s specimen was collected at 6 AM—3 hours ago. Is this acceptable? Explain your answer. Rosa also notes that the specimen collected in the sterile container from Ms. Hillman is marked “CCMS.” Why is this important?

ROUTINE URINALYSIS

Physical Examination of the Urine

The first part of a complete UA is assessment of the physical properties of the urine and measurement of selected chemical constituents that are diagnostically important (Table 52-2 and Procedure 52-3).

Appearance

Color. Normal urine is a shade of yellow, ranging from pale straw to yellow to amber. The color depends on the concentration
of the pigment urochrome and the amount of water in the spec-
imen. A dilute specimen should be pale, and a more con-
centrated specimen should be a darker yellow. Variations in color may be
caused by diet, medication, and disease. Abnormal colors may be
related to pathologic or nonpathologic factors (Table 52-3).

**Turbidity.** Both normal and abnormal urine specimens may
range in appearance from clear to very cloudy. Cloudiness may
be caused by cells, bacteria, yeast, vaginal contaminants, or crys-
tals. Often a urine specimen that was clear when voided becomes
cloudy as it cools, as crystals form and precipitate.

**Volume**
The amount of urine is rarely measured on a random specimen.
With a timed specimen, volume is measured by pouring the

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**PROCEDURE 52-2**

**Instruct Patients According to Their Needs: Instruct a Patient in the Collection of a Clean-Catch Midstream Urine Specimen**

**GOAL:** To collect a contaminant-free urine sample for culture or analysis using the clean-catch midstream specimen (CCMS) technique.

**EQUIPMENT and SUPPLIES**

- Sterile container with lid and label
- Antiseptic towelettes
- Patient record

**PROCEDURAL STEPS**

1. Label the container and give the patient the supplies (Figure 1).
   **PURPOSE:** Labeling the container prevents a possible mix-up of specimens.
2. Explain the following instructions to adult patients or to the guardians of pediatric patients, being sensitive to privacy issues.
3. **Obtaining a Clean-Catch Midstream Specimen (Female Patient)**
   1. Wash your hands and open the towelette packages for easy access.
   2. Remove the lid from the specimen container, being careful not to touch the inside of the lid or the inside of the container. Place the lid, facing up, on a paper towel.
      **PURPOSE:** The lid and container must be handled carefully to maintain the sterility of the container and prevent contamination of the urine sample.
   3. Remove your underclothing and sit on the toilet.
   4. Expose the urinary meatus by spreading apart the labia with one hand (Figure 2, A).

5. Cleanse each side of the urinary meatus with a front-to-back motion, from the pubis to the anus. Use a separate antiseptic wipe to cleanse each side of the meatus.
   **PURPOSE:** Cleansing the area around the urinary meatus prevents contamination of the urine sample. Wiping in one stroke from front to back prevents the passage of microorganisms from the anal region to the area around the urinary meatus.

6. Cleanse directly across the meatus, front-to-back, using a third antiseptic wipe (see Figure 2, A).

7. Hold the labia apart throughout this procedure.

8. Void a small amount of urine into the toilet (Figure 2, B).
   **PURPOSE:** Allowing the initial flow of urine to pass into the toilet flushes the opening of the urethra.

9. Move the specimen container into position and void the next portion of urine into it. Fill the container half way. Remember, this is a sterile container. Do not put your fingers on the inside of the container.

10. Remove the cup and void the last amount of urine into the toilet. (This means that the first part and the last part of the urinary flow have been excluded from the specimen. Only the middle portion of the flow is included.)
11. Wipe in your usual manner, redress, and return the sterile specimen to the place designated by the medical facility.

**Obtaining a Clean-Catch Midstream Specimen (Male Patients)**

1. Wash your hands and expose the penis.
2. Retract the foreskin of the penis (if not circumcised).
3. Cleanse the area around the glans penis (meatus) and the urethral opening by washing each side of the glans with a separate antiseptic wipe (Figure 3, A).
4. Cleanse directly across the urethral opening using a third antiseptic wipe.
5. Void a small amount of urine into the toilet or urinal (Figure 3, B).
6. Collect the next portion of the urine in the sterile container, filling the container half way without touching the inside of the container with the hands or the penis (Figure 3, C).
7. Void the last amount of urine into the toilet or urinal.
8. Wipe and redress.
9. Return the specimen to the designated area.

**PURPOSE:** Instructions must be understood if they are to be followed correctly. By talking to the patient, you can determine whether the patient understands or has any questions.

**Processing a Clean-Catch Urine Specimen**

1. Document the date and time and the collection type.
2. Process the specimen according to the physician's orders. Perform urinalysis in the office or prepare the specimen for transport to the laboratory. If it is to be sent to an outside laboratory, complete the following steps:
   - Make sure the label is properly completed with patient information, date, time, and test ordered.
   - Place the specimen in a biohazard specimen bag.
   - Complete a laboratory requisition and place it in the outside pocket of the specimen bag.
   - Keep the specimen refrigerated until pickup.
   - Document that the specimen was sent.

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**TABLE 52-1  Changes in Urine at Room Temperature**

<table>
<thead>
<tr>
<th>CONSTITUENT</th>
<th>CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity</td>
<td>Becomes cloudy as crystals precipitate and bacteria multiply</td>
</tr>
<tr>
<td>Color</td>
<td>May change if pH becomes alkaline</td>
</tr>
<tr>
<td>pH</td>
<td>Becomes alkaline as bacteria form ammonia from urea</td>
</tr>
<tr>
<td>Glucose</td>
<td>Decreases as it is metabolized by bacteria</td>
</tr>
<tr>
<td>Ketones</td>
<td>Decrease because of evaporation</td>
</tr>
<tr>
<td>Bilirubin and urobilinogen</td>
<td>Undergo degradation in light</td>
</tr>
<tr>
<td>Blood</td>
<td>May hemolyze; false-positive results are possible because of bacterial peroxidase</td>
</tr>
<tr>
<td>Nitrite</td>
<td>May become positive as bacteria multiply and reduce nitrate</td>
</tr>
<tr>
<td>Casts</td>
<td>Lyse or dissolve in alkaline urine</td>
</tr>
<tr>
<td>Cells</td>
<td>Lyse or dissolve in alkaline urine</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Multiply twofold approximately every 20 minutes</td>
</tr>
<tr>
<td>Yeast</td>
<td>Multiply</td>
</tr>
<tr>
<td>Crystals</td>
<td>Precipitate as urine cools; may dissolve if pH changes</td>
</tr>
</tbody>
</table>
entire collection into a large, graduated cylinder. Generally, it is not accurate enough to use the markings on the side of the collection container. Once the volume has been measured and recorded, a portion of well-mixed specimen, called an aliquot, is removed for testing. The remainder is discarded or stored, depending on the preference of the laboratory.

![Figure 52-3: BD Vacutainer urine preservation tubes. (Courtesy Becton, Dickinson & Company, Franklin Lakes, N.J.)](image)

The normal volume of urine produced every 24 hours varies according to the age of the individual. Infants and children produce smaller volumes than adults. The normal adult volume is 750 to 2,000 mL in 24 hours; the average amount is about 1,500 mL. Excessive production of urine is called polyuria. This is common in diabetes and certain kidney disorders. Oliguria is insufficient production of urine, which can be caused by dehy-

<table>
<thead>
<tr>
<th>TABLE 52-2 Components of Macroscopic Urinalysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHYSICAL PROPERTIES</strong></td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Clarity</td>
</tr>
<tr>
<td>Specific gravity</td>
</tr>
<tr>
<td>Volume*</td>
</tr>
<tr>
<td>Odor*</td>
</tr>
<tr>
<td>Foam*</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>Leukocyte esterase</td>
</tr>
</tbody>
</table>

*Not always assessed.

**PROCEDURE 52-3**

Perform a Urinalysis and Patient Screening Using Established Protocols: Assess the Urine for Color and Turbidity—the Physical Test

**GOAL:** To assess and record the color and clarity of a urine specimen.

**EQUIPMENT and SUPPLIES**

- Urine specimen
- Centrifuge tube
- Disposable gloves
- Biohazard container
- Patient's record

**PROCEDURAL STEPS**

1. Sanitize your hands and put on gloves.
2. Mix the urine by swirling.
   **PURPOSE:** Suspended substances settle when urine stands. If urine is not mixed before assessment of appearance, the finding will be incorrect.
3. Label a centrifuge tube if a complete urinalysis is being done.
   **PURPOSE:** If a complete urinalysis is to be done, a portion of the specimen will be centrifuged for microscopic examination. The centrifuged specimen must be labeled to prevent specimen confusion.
4. Pour the specimen into a standard-sized centrifuge tube.
   **PURPOSE:** Standard-sized containers are better for assessing color and clarity results.
5. Assess and record the color (Figure 1):
   - Pale straw
   - Dark yellow
   - Yellow
   - Amber
6. Assess the clarity:
   - Clear—no cloudiness
   - Slightly turbid—can see light print through tube
   - Moderately turbid—can see only dark print through tube
   - Very turbid—cannot see through tube
7. Clean the work area, remove your gloves, dispose of the gloves and procedure supplies in a biohazard waste container, and sanitize your hands.
   **PURPOSE:** To ensure infection control.
8. Record the results in the patient's record.
   **PURPOSE:** A procedure is considered not done until it is recorded.
### TABLE 52-3 Causes of Urine Colors

<table>
<thead>
<tr>
<th>COLOR</th>
<th>PATHOLOGIC CAUSE</th>
<th>NONPATHOLOGIC CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>Diabetes</td>
<td>Diuretics; high fluid intake (coffee, beer)</td>
</tr>
<tr>
<td>Amber</td>
<td>Dehydration</td>
<td>Excessive sweating; low fluid intake</td>
</tr>
<tr>
<td>Bright yellow</td>
<td></td>
<td>Carotene, vitamins</td>
</tr>
<tr>
<td>Red</td>
<td>Blood, porphyrins</td>
<td>Menstruation, beets, dyes, drugs</td>
</tr>
<tr>
<td>Orange-yellow</td>
<td>Bile, hepatitis</td>
<td>Pyridium (phenazopyridine hydrochloride), dyes, drugs</td>
</tr>
<tr>
<td>Greenish yellow</td>
<td>Bile, hepatitis</td>
<td>Senna, cascara, rhubarb</td>
</tr>
<tr>
<td>Reddish brown</td>
<td>Old blood, methemoglobin</td>
<td>Levodopa</td>
</tr>
<tr>
<td>Brownish black</td>
<td>Methemoglobin, melanin</td>
<td>Amorphous urates</td>
</tr>
<tr>
<td>Salmon pink</td>
<td></td>
<td>Amorphous phosphates</td>
</tr>
<tr>
<td>White (milky)</td>
<td>Fats, pus</td>
<td>Vitamin B, drugs, dyes</td>
</tr>
<tr>
<td>Blue-green</td>
<td>Biliverdin, infection with Pseudomonas organisms</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 52-4** Dark amber urine with foam indicates possible increased protein and possible hematuria.

**Foam**

Normally the presence of foam is not recorded, but careful observation of this property can be a significant clue to an abnormality. Foam is the presence of small bubbles that persist for a long time after the specimen has been shaken; they must not be confused with any bubbles that rapidly disperse. White foam can indicate the presence of increased protein (Figure 52-4). Greenish yellow foam can mean bilirubinuria. Care should be taken in handling such urines, because the color of the foam may indicate that the patient has viral hepatitis.

**Odor**

As with foam, odor is not normally recorded but can be an important clue to metabolic disorders. Normal urine is said to be aromatic. Changes in the odor of urine may be caused by disease, the presence of bacteria, or diet. The odor of the urine of a patient with uncontrolled diabetes is described as fruity because of the presence of ketones, which are the products of fat metabolism. An ammonia or putrid smell in the urine can be caused by an infection or may be noted in urine that has been allowed to stand before being tested. The bacteria break down the urea in the urine to form ammonia. Foods such as asparagus and garlic also can produce an abnormal odor in the urine. Urine from a child with phenylketonuria (PKU) is said to smell "mousey." PKU is a rare hereditary condition in which the amino acid phenylalanine is not properly metabolized, which can lead to severe mental retardation. Accumulation of phenylalanine in the blood and urine gives body fluids an odor like wet fur. (Blood sampling for PKU is discussed in Chapter 54.)

**Specific Gravity**

Specific gravity is the weight of a substance compared with the weight of an equal volume of distilled water. In UA, it is the rough measurement of the concentration, or amount, of substances dissolved in urine. The specific gravity of distilled water is 1.000. The normal specific gravity of urine ranges from 1.005 to 1.030, depending on the patient's fluid intake. Most samples fall between 1.010 and 1.025. The urine specific gravity indicates whether the kidneys are able to concentrate the urine and is one of the first indications of kidney disease. The presence of glucose, protein, or an x-ray contrast medium used in diagnostic studies also may increase the specific gravity of urine. To measure the specific gravity of urine, laboratories may use a urinometer, a refractometer, or a chemical reagent strip.

A urinometer is a sealed glass float with a calibrated paper scale in its stem (Figure 52-5). According to guidelines established by the Occupational Safety and Health Administration (OSHA), urinometers containing mercury must be replaced, because mercury is a hazardous waste. With a slight spinning motion, the urinometer is placed in a cylinder containing a urine sample, and the value is read at the meniscus of the urine. Enough urine must be used to suspend the float freely, usually about 20 to 25 mL. If the sample is insufficient to float the
A urinometer, a refractometer can be used, or "QNS" (quantity not sufficient) can be recorded.

A urinometer is fragile, and jarring can cause the paper scale in the stem to shift, resulting in erroneous readings. Because a damaged urinometer occasionally loses its calibration, the calibration should be checked daily with distilled water. The specific gravity of the distilled water should calibrate at 1.000 at 20°C (68°F; room temperature). For example, if the urinometer reads 1.002 in distilled water, 0.002 must be subtracted from the urine readings. However, it is better to replace the instrument. For each 3°C (37.4°F) the water temperature measures above 20°C (68°F), 0.001 must be added to the reading. For each 3°C (37.4°F) the water temperature measures below 20°C (68°F), 0.001 must be subtracted from the reading. Use a laboratory thermometer to determine the water temperature. The urinometer method, although considered the gold standard of specific gravity testing, uses a large volume of urine and results in contamination of several pieces of glassware. For these reasons, it is rarely used in modern laboratories.

A refractometer measures the refraction of light through solids in a liquid. The result is called the refractive index, which for our purposes is the same as specific gravity (Figure 52-6). The refractometer is both faster and easier to use than the urinometer and requires only a drop of urine. One drop of well-mixed urine is placed under the hinged cover of the instrument, and the value is read directly from a scale viewed through an ocular. The refractometer must be calibrated daily with distilled water, which should read 1.000 (Procedure 52-4). Note that the measurement of specific gravity carries no unit of measure after the number.

The reagent strip (dipstick) test is the method most commonly used in the physician's office laboratory (POL), and it is considered a Clinical Laboratory Improvement Amendments (CLIA)-waived test. The pad on the strip contains a chemical that is sensitive to positively charged ions, such as sodium (Na+) and potassium (K+). The strip detects specific gravity in the range of 1.005 to 1.030.

**CRITICAL THINKING APPLICATION 52-3**

- The requisitions accompanying the urine specimens indicate that all three require a UA. Rosa performs the physical analysis and notes that Mrs. Carpenter's urine, which requires the pregnancy test, is amber, whereas the other two specimens are pale yellow. What are possible explanations for Rosa's observations? Should Rosa be concerned about the darker color of Mrs. Carpenter's urine?
- Ms. Hillman's urine is turbid, whereas Mr. Park's urine is clear. What might be causing the cloudiness in Ms. Hillman's urine? Is a cloudy urine cause for concern?

**Chemical Examination of Urine**

Tests can be performed on urine to detect the presence of certain chemicals, which can provide valuable information to the physician. In certain situations, these chemical test results can be critical to the diagnosis.

Reagent strip testing is the most widely used technique for detecting chemicals in the urine (Procedure 52-5); these strips
Perform Quality Control Measures: Measure the Urine Specific Gravity with a Refractometer

**GOAL:** To calibrate a refractometer and measure the refractive index of urine. A refractometer is also known as a total solids (TS) meter.

**EQUIPMENT and SUPPLIES**
- Urinary refractometer
- Distilled water
- Disposable pipet
- Biohazard waste container
- Disposable gloves
- Patient's record

**PROCEDURAL STEPS**

1. Sanitize your hands and assemble the equipment while the urine specimen reaches room temperature.  
   **PURPOSE:** Measuring the specific gravity of cold or warm urine may alter the results.
2. Put on gloves and mix the urine specimen in the collection container.  
   **PURPOSE:** Mixing the urine resuspends solids that have settled during storage.
3. Using a disposable pipet, apply a drop of water to the prism of the refractometer (see Figure 52-6) by lifting the plastic cover. Close the cover and point the device toward a light source, such as a window or lamp. Look into the refractometer and rotate the eyepiece so that the scale can be clearly read. The scale reads from 1.000 to 1.035 in increments of 0.001.
4. Calibrate the refractometer by inserting the small screwdriver provided by the manufacturer in the screw on the underside of the instrument. Turn the screw so that the line is positioned over 1.000 (Figure 1).  
   **PURPOSE:** This step ensures that the refractometer has been calibrated properly and must be performed daily.
5. Wipe the prism with a soft, lint-free tissue and apply a drop of mixed urine. Close the cover, point the device at a light source, and read the specific gravity on the scale. Discard the pipet in a biohazard waste container. The value for the specific gravity shown in Figure 52-7 is 1.020. Note that specific gravity has no units after the value.

**PURPOSE:** A soft cloth should be used to prevent scratching of the glass prism.
6. Wipe the urine from the prism with a disposable, soft, lint-free tissue between samples. When finished, clean with tissue moistened with alcohol or with a disposable alcohol wipe. Discard these tissues in a biohazard waste container.

**PURPOSE:** Urine, a biohazardous material, must be removed from the prism. The prism must be decontaminated after use.
7. Document the results in the patient's record and discard the urine sample.  
   **PURPOSE:** A procedure is not considered finished until it is recorded.
8. Remove and discard your gloves in the biohazard container and sanitize your hands.

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Figure 1 From Stepp CA, Woods MA: Laboratory procedures for medical office personnel, Philadelphia, 1998, Saunders.

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are available in a variety of types (Figure 52-7). Generally, they are plastic strips to which one or more pads containing chemicals are attached. Tests are available for pH, specific gravity, vitamin C, leukocyte esterase, protein, ketones, glucose, blood, bilirubin, nitrite, urobilinogen, phenylketones, and other chemicals. The presence or absence of these chemicals in the urine provides information on the status of carbohydrate metabolism, liver and kidney function, and the patient's acid-base balance.

Reagent strips are designed to be used once and then discarded. The directions for each strip are included inside the package, and these instructions must be followed exactly to obtain accurate results. A color comparison chart is provided on the label of the container. In addition to reagent strips, various tablet tests are available.

All strips and tablets must be kept in tightly closed containers in a cool, dry area and should be removed immediately before testing. To prevent contamination of the bottle, never touch a strip that has been exposed to urine to the color comparison chart. If both a UA and a C&S have been ordered for a specimen, the urine must be cultured before the UA is started, because introducing a reagent strip into the urine contaminates it.
PROCEDE 52-5

Perform a Urinalysis and Patient Screening Using Established Protocols: Test Urine with Chemical Reagent Strips—the Chemical Urinalysis

GOAL: To perform chemical testing on a urine sample.

EQUIPMENT and SUPPLIES
- Urine specimen
- Reagent strips
- Timer
- Biohazard waste container
- Eye protection
- Disposable gloves
- Patient’s record

PROCEDURAL STEPS

1. Sanitize your hands. Put on nonsterile gloves and eye protection.
   PURPOSE: To ensure infection control.

2. Check the time of collection, the container, and the mode of preservation.
   PURPOSE: Proper specimen identification and screening of specimens for appropriate collection containers and collection procedures prevent testing of inappropriate specimens.

3. If the specimen has been refrigerated, allow it to warm to room temperature.
   PURPOSE: Certain tests are temperature dependent. Testing of cold specimens may cause false-negative results.

4. Check the reagent strip container for the expiration date.
   PURPOSE: Do not use expired reagents.

5. Remove the reagent strip from the container. Hold it in your hand or place it on a clean paper towel. Recap the container tightly.
   PURPOSE: Test strips are sensitive to moisture and light and must be stored in tightly sealed containers. Contamination from chemical residues on countertops can affect results.

6. Compare nonreactive test pads with the negative color blocks on the color chart on the container.
   PURPOSE: Discolored pads indicate that the product has not been properly stored and must not be used for testing.

7. Thoroughly mix the specimen by swirling.
   PURPOSE: If settling occurs, certain elements may not be detected.

8. Following the manufacturer’s directions, note the time, dip the strip into the urine and then remove it.
   PURPOSE: Tests are time dependent. Some pads darken over time.

9. Quickly remove the excess urine from the strip by touching the side of the strip to a paper towel or the side of the urine container.
   PURPOSE: Excess urine on the strip or prolonged dipping time affects test results.

10. Hold the strip horizontally. At the required time, compare the strip with the appropriate color chart on the reagent container (Figure 1). Document on the reagent strip flow sheet each result as it is read. Alternatively, the strip can be placed on a paper towel.
    PURPOSE: Holding the strip horizontally prevents runoff from one test pad to another and prevents interference from the mixing of chemicals in the test pads.

11. Read the concentration by comparing the strip to the color chart on the side of the bottle. Do not touch the strip to the bottle.
    PURPOSE: Timing is critical. Allowing the strip to come in contact with the bottle contaminates the bottle.

12. Clean the work area, remove your gloves, and sanitize your hands. If a paper towel was used, dispose of it, the reagent strip, and your gloves in the biohazard container.
    PURPOSE: To ensure infection control.

    PURPOSE: A procedure is considered not done until it is recorded.

Figure 1

pH
The pH is a measurement of the degree of acidity or alkalinity of the urine. A urine specimen with a pH of 7 is neutral (Figure 52-8). A value below 7 indicates acidity, and one above 7 indicates alkalinity. Normal, freshly voided urine may have a pH range of 5.5 to 8. The urinary pH varies with an individual’s metabolic status, diet, drug therapy, and disease. In the case of gross bacteriuria, the urine pH is alkaline as a result of bacterial conversion of urea to ammonia. Knowing the pH of the urine also assist in the identification of crystals if they are found in the urine sediment.

Glucose
Glucose is filtered at the glomerulus, but under normal conditions most of it is reabsorbed in the tubules. The minute quantities normally present in the urine are not detected by reagent
strips and tablets. Detectable glycosuria occurs whenever the renal tubules cannot reabsorb the filtered glucose load. A positive glucose finding is common in urine from patients with diabetes and may be the first indication of the disease. The reagent strip glucose testing method is based on an enzymatic reaction. It detects only glucose; in other words, it is specific for glucose.

**Protein**

Protein in the urine in detectable amounts is called proteinuria and is one of the first signs of renal disease. We normally excrete a small amount of protein every day; proteinuria may be light to heavy, constant or sporadic. It may be affected by posture; in orthostatic proteinuria, protein is excreted only when the patient is in an upright position. Generally, first morning specimens from these patients are negative, but protein is found in urine passed throughout the day. Proteinuria is a common finding in pregnancy. It also is almost always present after heavy exercise. The reagent strip is highly sensitive to urinary albumin and less sensitive to hemoglobin, immunoglobulin, and mucoproteins.

**Ketones**

Ketones are the end-product of fat metabolism in the body. Acetoacetate, acetone, and beta-hydroxybutyric acid are collectively called ketone bodies, or ketones. Ketonuria is common with starvation, low-carbohydrate diets, excessive vomiting, and diabetes melitus. Because ketones evaporate at room temperature, urine should be tested immediately, or the specimen should be tightly covered and refrigerated. The reagent strip detects only acetone. The Acestest, discussed later in this chapter, can be used to detect both acetone and acetoacetate.

**Blood**

The presence of blood in the urine may indicate infection or trauma to the urinary tract or bleeding in the kidneys. The blood test pad on the reagent strip reacts with three different blood constituents: intact red blood cells, hemoglobin from red blood cells, and myoglobin, a hemoglobin-like molecule that transports oxygen in muscle tissue.

Hematuria is the presence of intact red blood cells in urine. The color reaction on the reagent strip ranges from yellow through green to dark green when hematuria is present, revealing a speckled appearance. Hematuria can be caused by irritation of the ureters, bladder, or urethra. It also is a common finding in cystitis and in individuals passing kidney stones. A random specimen may contain blood from vaginal contamination if the woman is menstruating.

Hemoglobinuria is the presence of hemolyzed red blood cells. True hemoglobinuria is rare. It occurs as a result of intravascular red blood cell destruction and can be caused by transfusion reactions, malaria, drug reactions, snake bites, and severe burns. Myoglobinuria occurs when muscle tissue is damaged or injured, such as in crushing injuries, myocardial infarctions, and contact sports. Patients with muscular dystrophy often have myoglobinuria. Hemoglobinuria cannot be distinguished from myoglobinuria by reagent strip testing; both cause a uniform change of color from light green to dark green on the strip.

**Bilirubin and Urobilinogen**

Bilirubin is a product of the breakdown of hemoglobin. Hemoglobin is released from old red blood cells and is gradually converted to bilirubin in the liver, then further to urobilinogen in the intestines. Bilirubin is a bile pigment not normally found in urine. Its presence in urine is one of the first signs of liver disease.
or other disease in which the liver may be involved, such as infectious mononucleosis.

Bilirubinuria can occur even before jaundice or other symptoms of liver disease are evident. It is the result of liver cell damage or obstruction of the common bile duct by stones or neoplasms (tumors). Excessive bilirubin colors the urine yellow-brown to greenish orange. Because direct light causes decomposition of bilirubin, urine samples must be protected from light until testing is complete.

Urobilinogen normally is present in urine in small amounts. Increases are seen with increased red blood cell destruction and in liver disease. With total obstruction of the bile duct, no urobilinogen is formed in the intestines, none is reabsorbed into the circulation, and therefore none is present in the urine. Reagent strip methods cannot detect a decrease in urobilinogen.

**Nitrite**

Nitrite occurs in urine when bacteria break down nitrate, a common component of urine. A positive nitrite test result may indicate the presence of a urinary tract infection (UTI). However, not all bacteria are able to reduce nitrate to nitrite. Negative nitrite test results also can occur when bacteria are insufficient or when the urine has not incubated in the bladder long enough for the reaction to occur. *Escherichia coli*, the organism that causes most UTIs, reduces nitrate to nitrite. False-positive results can occur if a specimen is allowed to sit at room temperature and contaminating bacteria multiply. False-negative results may occur if the bacteria further metabolize the nitrite they have produced to ammonia.

**Leukocyte Esterase**

Leukocytes (white blood cells) occur in urine with infections of the urinary tract. They also can be contaminants from the vagina. The leukocyte esterase test on reagent strips detects intact and lysed polymorphonuclear white blood cells. However, it does not detect mononuclear white blood cells, which occasionally are present during infections. The test does not react with the small numbers of white blood cells found in normal urine.

**Limitations of Reagent Strip Testing**

The reagent strip is a reliable method of chemical analysis of urine if used properly. The normal urine reference ranges for a reagent strip can be found in Table 52-4. Error can arise from a number of sources; for example, if the strip is soaked excessively in the specimen, chemicals in the pads may be diluted. If the strip is not held horizontally while read, colors from one pad may bleed onto another. Finally, certain chemicals, such as ascorbic acid, may affect the results of nitrite, glucose, bilirubin, and occult blood tests. Normal levels of vitamin C do not interfere, but if a person consumes large amounts of the vitamin, a special strip can be used to detect interfering levels of vitamin C. If an elevated level is found, the patient should be instructed to discontinue vitamin C intake for 24 hours and then another urine specimen should be collected for testing.

Visual interpretation of color on the reagent strip pads is likely to vary among individuals, and some laboratories use automated instruments to read the strips (Figure 52-9). Several companies manufacture instruments that use the principle of reflectance photometry in the analysis of reagent strip color. Once the strip has been placed in the instrument, a microprocessor controls the movement of the strip into the reflectometer. There, light of specific wavelengths is beamed onto the strip. Some light is absorbed, and some scatters or is reflected. The amount of reflected light is analyzed by the microprocessor and converted into a digital reading, and the result is printed out (Figure 52-10).

The advantage of this method is that timing and color interpretation are consistent. The disadvantage is that the instrument is not able to identify and compensate for highly pigmented urine, leading to false-positive results. The medical assistant should be aware of this and should manually test urine specimens that are darkly pigmented.

**CRITICAL THINKING APPLICATION 52-4**

- **Rosa prepares to do the chemical examination of the three urine specimens. Remember, Dr. Hill has ordered a UA on the specimen from Mr. Parks, a UA and pregnancy test on the specimen from Mrs. Carpenter, and a UA and C&S on the specimen from Ms. Hillman. Should Rosa proceed with the chemical analysis of each specimen in exactly the same manner? Explain your answer.**

- **On completing the chemical analysis of the three specimens, Rosa notes several differences among the samples. Mrs. Carpenter’s sample has a high specific gravity. Ms. Hillman’s sample reveals an elevated nitrite level, a pH of 7.8, and an elevated leukocyte esterase reading. Mr. Parks’s test results reveal elevated glucose and ketone levels and a specific gravity of 1.025. Based on this information, what are the probable reasons each of these patients visited Dr. Hill today?**

**Microscopic Examination of Urine Sediment**

Microscopic examination of urine (Procedure 52-6) consists of categorizing and counting cells, casts, crystals, and miscellaneous constituents of the sediment obtained when a measured portion of urine is centrifuged. The test is not categorized as CLIA waived; therefore, it would not be performed by a medical assistant without additional training and rigid compliance with CLIA quality assurance protocols for the laboratory, including periodic proficiency testing. However, medical assistants should be famil-
TABLE 52-4 Normal Urine Reference Ranges for Reagent Strips

<table>
<thead>
<tr>
<th>REFERENCE</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Pale yellow to straw</td>
</tr>
<tr>
<td>Clarity</td>
<td>Clear to slightly turbid</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.001-1.035</td>
</tr>
<tr>
<td>pH</td>
<td>4.6-8</td>
</tr>
<tr>
<td>Protein (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Ketone (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Bilirubin (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Blood (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Nitrite (mg/dl)</td>
<td>NEG</td>
</tr>
<tr>
<td>Urobilinogen (Ehrlich units)</td>
<td>0.1-1</td>
</tr>
<tr>
<td>White blood cells</td>
<td>NEG</td>
</tr>
</tbody>
</table>

Casts are formed when protein accumulates and precipitates in the kidney tubules and is washed into the urine. The protein takes on the size and shape of the tubules; hence the term casts. Casts are cylindrical, with flat or rounded ends, and are classified according to the substances observed in them. Certain types of casts are associated with renal pathologic conditions; others are physiologic and are generally caused by strenuous exercise. Casts are counted and reported under low-power magnification, but occasionally high-power magnification is needed to identify the type. Because casts tend to migrate to the edges of the coverslip, this area should be examined closely. Because casts dissolve in alkaline urine on standing, examination of a fresh urine specimen is very important.

Hyaline casts are pale, transparent, cylindrical structures that have rounded ends and parallel sides (Figure 52-11). Hyaline casts will be missed entirely if the light is not reduced at the condenser. They are formed when urine flow through individual

iar with preparing the urine for this test and with the possible results. The clear upper portion of the specimen is called the supernatant. It is poured off, and a drop of the well-mixed sediment is examined under a microscope. The sediment may be stained with a supravital sediment stain to give greater contrast to the formed elements. The most commonly used stain is the Sternheimer-Malbin stain, which consists of crystal violet and safranin. This stain assists in the identification of formed elements by enhancing the detail of internal cellular structure.

Microscopic observation is performed with a bright field, phase contrast, or polarizing microscope. With a traditional bright field microscope, correct light adjustment is essential. The light must be reduced by closing the condenser iris diaphragm to increase the contrast. The condenser should be lowered slightly. Bright field microscopy is enhanced by the use of stains. Phase contrast microscopy converts variations in the refractive index into variations in contrast by fitting a bright field microscope with a special device known as an annular ring, which enhances contrast in living cells and low refractive index components. The polarizing microscope is used most often in the UA laboratory to confirm the presence of fat, specifically cholesterol, and for identifying crystals.

Many formed elements are found in the urine. Some are significant; others are not. Most important, the microscopic examination should correlate with the physical and chemical analyses. For example, if the presence of red blood cells is confirmed on the reagent strip, red blood cells should be visible on the microscopic examination, and the urine may appear pink or red tinged.
PROCEDURE 52-6

Perform a Urinalysis: Prepare a Urine Specimen for Microscopic Examination

GOAL: To perform a microscopic examination of urine to determine the presence of normal and abnormal elements.

EQUIPMENT and SUPPLIES

- Urine specimen
- Centrifuge tube
- Centrifuge
- Disposable pipet
- Microscope slide and coverslip
- Microscope
- Permanent marker
- Disposable gloves
- Face protection
- Biohazard waste container
- Patient's record

PROCEDURAL STEPS

1. Sanitize your hands. Put on nonsterile gloves and face protection.
   PURPOSE: To ensure infection control.
2. Gently mix the urine specimen.
   PURPOSE: If the urine is not well mixed, elements that have settled to the bottom of the specimen container will be missed.
3. Pour 10 mL of urine into a labeled centrifuge tube and cap the tube.
4. Place the tube in the centrifuge (Figure 1).
5. Place another tube containing 10 mL of water in the opposite cup.
   PURPOSE: For proper operation, centrifuges must be carefully balanced. If not properly balanced, damage to the instrument can occur.
6. Secure the lid and centrifuge for 5 minutes or for the time specified for your instrument.
   PURPOSE: Timing varies based on the speed and the size of the centrifuge head.
7. Remove the tube from the centrifuge after the instrument has come to a full stop.
8. Pour off the clear supernatant from the top of the specimen by inverting the centrifuge tube over the sink drain. Do not turn the tube upright until the supernatant has been fully decanted (Figure 2).
9. Prevent the loss of sediment down the drain.
   PURPOSE: The sediment is what will be examined under the microscope.
10. Thoroughly mix the sediment by grasping the tube near the top and rapidly flicking it with the fingers of the other hand until all sediment is thoroughly resuspended (Figure 3).
   PURPOSE: Elements centrifuge at different rates. Failure to mix the entire sediment completely will cause errors in quantification.
11. Transfer one drop of sediment to a clean, labeled slide using a clean, disposable transfer pipet.
12. Place a clean coverslip over the drop and place the slide on the microscope stage. Remove face protection.
   The remaining steps typically are performed by the healthcare practitioner. Medical assistants should not perform the microscopic examination unless they are specially trained to do so.
13. Focus under low power and reduce the light.
   PURPOSE: Mucus and casts are easily missed if reduced light is not used. Constant focusing helps locate them.
14. First, scan the entire coverslip for abnormal findings.
   PURPOSE: Casts tend to migrate to the edges of the coverslips.

Figure 1 (From Stapp CA, Woods MA: Laboratory procedures for medical office personnel, Philadelphia, 1998, Saunders.)
Figure 2 (From Stapp CA, Woods MA: Laboratory procedures for medical office personnel, Philadelphia, 1998, Saunders.)
Figure 3 (From Stapp CA, Woods MA: Laboratory procedures for medical office personnel, Philadelphia, 1998, Saunders.)
PROCEDURE 52-6—cont'd

15. Examine five low-power fields. Count and classify each type of cast seen, if any, and note mucus if present.
   **PURPOSE:** Choose five fields so that one is selected from each corner of the coverslip and the last one is chosen from the middle of the coverslip. If you move to an area and nothing is there, record a zero.

16. Switch to high-power magnification and adjust the light.
   **PURPOSE:** As magnification increases, more light is needed.

17. In five high-power fields, count the following elements: red blood cells, white blood cells, and round, transitional, and squamous epithelial cells.

18. In the same five fields, report the following as few, moderate, or many: crystals (identify and report each type seen separately), bacteria (identify as rods or cocci), sperm, yeast, and parasites.
   **PURPOSE:** Few, moderate, and many are more easily and universally understood than are exact numbers.

19. Average the five fields and report the results.
   **NOTE:** Steps 13 to 19 are performed only by qualified personnel.

20. Clean up the work area, remove your gloves, dispose of contaminated materials in a biohazard container, and sanitize your hands.

   **PURPOSE:** A procedure is not considered finished until it is recorded.

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**FIGURE 52-11** Hyaline casts. (SidrStain, 400×.) (Modified from Bonewit-West K: Clinical procedures for medical assistants, ed 7, St Louis, 2008, Saunders.)

**FIGURE 52-12** White blood cell casts. (From Stepp CA, Woods MA: Laboratory procedures for medical office personnel, Philadelphia, 1998, Saunders.)


Nephrons is diminished. They can be found in the urine of individuals with kidney disease but also in the urine of people without such disease who have exercised heavily. Occasionally, hyaline casts have granular or cellular inclusions.

White blood cell casts are hyaline casts that contain leukocytes. White blood cells usually have a multilobed nucleus, which differentiates them from renal tubular epithelial cells, which have single, round nuclei. White blood cell casts are seen in pyelonephritis (Figure 52-12).

Finely and coarsely granular casts may be caused by exercise, but the presence of increased numbers may indicate renal disease. On close examination, granular casts show a hyaline matrix with coarse or fine granular inclusions. The granules are thought to be caused by protein aggregation or degeneration of cellular inclusions (Figure 52-13).

Red blood cell casts always indicate a pathologic condition and are highly diagnostic. These casts occur in glomerulonephritis. They are hyaline casts with embedded red cells, and their presence indicates damage to the glomerular membrane. They may appear brown as a result of the color of the red blood cells present (Figure 52-14).

Renal tubular epithelial cell casts contain embedded renal tubular epithelial cells. These casts are easily confused with white blood cell casts, particularly if the cells have started to degenerate.

Renal tubular epithelial cell casts are found when excessive damage has occurred. Causes are shock, renal ischemia, heavy-metal poisoning, certain allergic reactions, and nephrotoxic drugs (Figure 52-15).

Waxy casts are rarely seen. They appear as glassy, brittle, smooth, homogeneous structures. They usually are yellowish, have cracks or fissures, and have squared or broken ends. They
are considered to be degenerated cellular casts and are found in individuals with severe renal disease (Figure 52-16).

Occasionally more than one type of cell is found in a single cast. Mixed cellular casts have been reported, and absolute identification of the cell types present may be difficult.

**Cells**

Cells found in the urine include epithelial cells, which are derived from the lining of the genitourinary tract, and red blood cells and white blood cells from the bloodstream. Cells are classified and counted under high-power magnification.

Red blood cells may enter the urinary tract at any point of inflammation or injury. They may be found in normal urine in small numbers, usually fewer than one or two per high-power field. Persistent hematuria should be investigated. Red blood cells are pale, round, nongranular, and flat or biconcave (Figure 52-17). They are smaller than white blood cells and have no nucleus. In hypotonic (dilute) urine, they swell and burst. In hypertonic (concentrated) urine, they may crenate and wrinkle. When they crenate, they can be mistaken for white blood cells, because the wrinkled surface makes them appear granular. They often are confused with yeast (see Figure 52-24), oil droplets, and droplets of lens cleaner.

White blood cells, also called leukocytes, occasionally may be found in normal urine, but increased numbers (usually more than five cells per high-power field) are associated with inflammation or contamination of the specimen during collection. White blood cells are larger than red blood cells, have a granular appearance, and usually have a multilobed nucleus, although nuclear detail may not be evident. Most white blood cells in the urine are neutrophils (Figure 52-18).

Renal tubular or round epithelial cells are somewhat larger than white blood cells, are round or oval, and have a nucleus that
is single, large, oval, and sometimes eccentric. A few may be found in normal urine specimens, but their presence in increased numbers indicates tubular damage (Figure 52-19).

Transitional epithelial cells line the urinary tract from the renal pelvis to the upper portion of the urethra. They vary from slightly larger than a round epithelial cell to smaller than a squamous epithelial cell. They are round or oval and may have a tail. Occasionally, two nuclei are seen. When transitional cells are present in large numbers, a pathologic condition may exist (Figure 52-20).

Squamous epithelial cells line the lower portion of the genitourinary tract. When present in large numbers in female patients, they usually indicate vaginal contamination. Squamous epithelial cells are large, flat, irregular cells and are easily recognized under low-power magnification. They have a single, small, round, centrally located nucleus and often occur in sheets or clumps. Because of their flat nature, the edges of the cells often are rolled or folded (see Figure 52-23).

When identifying epithelial cells, it is helpful to remember the appearance of eggs; round epithelial cells resemble hard-boiled eggs that have been cut in half. Transitional forms resemble poached eggs, and squamous cells resemble fried eggs with large, runny whites.

**Crystals**

Crystals are common in urine specimens, particularly if the specimen has been allowed to cool. Cooling causes the solid crystals to precipitate out of the urine. The presence of most crystals is not clinically significant unless they are found in large numbers. With only very rare exceptions, abnormal crystals are seen in acidic urine. Abnormal crystals may be of metabolic origin and are present because of certain disease states or an inherited metabolic condition, or they may be of iatrogenic origin and are present as a result of medication or treatment. Identification of crystals begins with determination of the pH of the urine to ascertain whether the sample is acidic or alkaline. Next, the color, shape, and refractivity are observed. Viewing with a polarized or phase microscope or using a supravital stain can assist in identification. Often a history of medication intake and recent diagnostic testing is helpful.

Crystals are identified with the low-power and high-power lenses, and their presence is reported as occasional, few, moderate, or many per high-power field (Table 52-5). At times crystals can be amorphous. Amorphous urates (Figure 52-21) are salts of uric acid and are seen as shapeless granulation in acidic urine. Amorphous phosphates (Figure 52-22) are found in alkaline urine and are seen as fluffy white precipitate. Amorphous crystals often are
### TABLE 52-5 Normal and Abnormal Crystals Found in the Urine

<table>
<thead>
<tr>
<th>Abnormal Crystal</th>
<th>Normal Crystals (Acid Urine)</th>
<th>Normal Crystals (Alkaline Urine)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfonamide</td>
<td>Calcium oxalate</td>
<td>Ammonium bicarbonate</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>Tripel phosphate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uric acid</td>
<td></td>
</tr>
</tbody>
</table>

so profuse they obscure other formed elements in the sediment. Frequently crystals are difficult to identify without additional chemical testing, such as solubility testing in acid and base.

### Miscellaneous Findings

Oval fat bodies are formed when renal tubular epithelial cells or macrophages absorb fats. The fat droplets in the cells vary in size and are quite refractile. Oval fat bodies are characteristic of nephrotic syndrome and are best distinguished by using Sudan III stain, because they are easily confused with other elements (Figure 52-23).

Yeast in the urine may indicate vaginal contamination or infection of the urine with yeast (Figure 52-24). Yeast is common in the urine of patients with diabetes. Yeasts are easily confused with red blood cells; they usually are oval, may show budding, and are more refractile. To differentiate yeast from red blood cells, a drop of sediment is placed on the blood test pad of a reagent strip. Yeast does not react, but red blood cells do. Red blood cells dissolve when a drop of dilute acetic acid (regular white vinegar) is added to the sediment, but the yeast remains intact.

A few bacteria may be found in normal urine specimens. Heavy bacterial concentrations in the absence of white blood cells may indicate that the specimen was allowed to sit at room temperature and the bacteria multiplied. Urine specimens with a putrid odor, numerous white blood cells, and bacteria (Figure 52-25) are common with UTIs. The bacteria may be bacilli (rod shaped) or cocci (spheric) and are identified under high-power magnification. They are often motile.

Spermatozoa can be found in the urine specimens of both male and female patients. In the latter case, their presence represents vaginal contamination of the specimen. Sperm usually have pointed, oval heads and long, threadlike tails. They may be motile in fresh urine.

The most commonly encountered parasite in urine is *Trichomonas vaginalis* (Figure 52-26). It’s usually a vaginal contaminant but may also be found in urine specimens from male patients. When urine is fresh and warm, *Trichomonas* organisms may be motile and dart about rapidly. *Trichomonas* organisms are pear-shaped protozoa with four flagella. They are larger than round epithelial cells but smaller than squamous cells. *Trichomonas* organisms die when the specimen is cooled.

Mucous threads can be found in most urine specimens. They appear as pale, irregular, threadlike structures with tapered ends. Beginners often confuse hyaline casts with mucous threads. Increased numbers are seen with inflammation and in specimens contaminated with vaginal secretions (Figure 52-27).
Artifacts and contaminants often are found in urine sediment; training is required to differentiate them and to learn to ignore them. As a rule, structures that are apparent when you first view the sediment are unimportant. Starch granules are common artifacts simply because of the extensive use of powdered gloves in the laboratory. The granules are highly refractile and dimpled, resembling a pillow with a center button. Fibers also are common in the sediment and come from clothing, diapers, or digested plant material. Clothing fibers often are long and twisted and sometimes are colored. Diaper fibers can be confused with casts (Figure 52-28). Plant fibers appear in the urine as a result of fecal contamination (Figure 52-29). Hair is distinguishable not only because of the visible rough and fragmented cuticle, but also because of the size (Figure 52-30). Air bubbles are common if the coverslip was improperly placed over the sediment. Air bubbles are structureless and refractile and have a dark outline (Figure 52-31).

**Interpretation of the Microscopic Examination**

The medical assistant should understand how the findings of a microscopic examination of the sediment are reported. The sediment first is examined under the low-power objective and low light to locate casts, which generally are found around the edges of the coverslip. Ten to 15 low-power fields are scanned, and the number of casts is counted and reported. The high-power objective and increased light then are used to identify red and white blood cells, epithelial cells, yeasts, bacteria, and crystals. Ten to 15 high-powered fields should be scanned and the number counted, averaged, and reported. The method of counting varies consider-
ably among laboratories. It is important that all workers in the same laboratory use the same counting and reporting systems. Report the results of the microscopic examination as follows:

1. Separately total the number for each element counted, then average. (Casts, white blood cells, red blood cells, and the three categories of epithelial cells are counted, totaled, and averaged.) Casts, white blood cells, and red blood cells are reported using numeric ranges based on the average:
   - 0
   - 0-1
   - 1-2
   - 2-5
   - 5-10
   - 10-20 and so forth

   Epithelial cells are reported as occasional, few, moderate, or many, as follows:
   - 0
   - 0-3 Occasional
   - 3-6 Few
   - 6-12 Moderate
   - ≥12 Many

2. Estimate the remaining elements as occasional, few, moderate, or many, as follows:
   - Occasional Not seen in every field
   - Few Covers less than a quarter of the field
   - Moderate Covers approximately half of the field
   - Many Covers the entire field

   Do not report fibers, hair, talc granules, oil droplets, or other artifacts.

   Table 52-6 presents an example of the calculating and reporting of a microscopic UA examination.

### Quality Assurance and Quality Control in Urinalysis

The U. S. Food and Drug Administration (FDA) categorizes the chemical analysis of urine performed by an instrument or a reagent strip as a CLIA-waived test. The chemical analysis includes the reagent strip (dipstick) tests for bilirubin, glucose, hemoglobin or blood, ketones, leukocyte esterase, nitrite, pH, protein, specific gravity, and urobilinogen. To perform a microscopic UA procedure, a laboratory must be certified to perform moderate-complexity tests. Such a laboratory can also perform waived tests if they meet those qualifications (Procedure 52-7).

A commercially available control strip should be used to determine the reliability of the reagent strip used in chemical analysis. One such control strip is the Chek-Stix (Bayer, Tarrytown, New York). The plastic control strip has seven pads (Figure 52-32), each of which contains synthetic ingredients that mimic human urine when reconstituted in water. After reconstitution, a reagent strip is immersed in the solution and the results are compared with a chart that accompanies the Chek-Stix. Both positive and negative Chek-Stix are available (see Procedure 52-7).

Quality control is as important in the microscopic examination as in the chemical analysis of urine. To ensure consistency, standardized, commercially available systems can be used, such as the KOVA System (Hycor Biomedical, Garden Grove, California) or the UniSystem (Fisher Scientific, Hampton, New Hampshire). These systems may include specially designed, graduated centrifuge tubes with devices or pipets that allow easy decanting of supernatant and retention of an exact amount of sediment. They also use specially designed plastic slides with wells or coverslips that accept only a given amount of sediment. Whatever system is used, the Clinical and Laboratory Standards Institute (CLSI) recommends the following:

- The urine volume should be 12 mL.
- The specimen should be centrifuged for 5 minutes at a relative centrifugal force of 400 g (i.e., 400 times normal gravity).
- A standardized slide should be used to view the sediment.
- A consistent reporting format should be used.

### Additional Tests Performed on Urine

**Clinistest**

The glucose test on the reagent strip detects only glucose, the most common sugar found in the urine. However, sugars other
**TABLE 52-6** Calculating a Microscopic Urinalysis

<table>
<thead>
<tr>
<th>Field</th>
<th>Casts</th>
<th>Mucous</th>
<th>Squamous Epithelial Cells</th>
<th>WBC</th>
<th>RBC</th>
<th>Transitional Epithelial Cells</th>
<th>Round Epithelial Cells</th>
<th>Bacteria</th>
<th>Crystals</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Few</td>
<td>1</td>
<td>16</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Moderate (rads)</td>
<td>Calcium oxalate — few —</td>
<td>Uric acid — few —</td>
</tr>
<tr>
<td>2</td>
<td>1 hyaline</td>
<td>Few</td>
<td>3</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Many</td>
<td>Calcium oxalate — few —</td>
<td>Yeast</td>
</tr>
<tr>
<td>3</td>
<td>1 coarse granular</td>
<td>Moderate</td>
<td>3</td>
<td>21</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>Many</td>
<td>Calcium oxalate — few —</td>
<td>Yeast</td>
</tr>
<tr>
<td>4</td>
<td>1 coarse granular</td>
<td>Few</td>
<td>5</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>Moderate (rads)</td>
<td>Calcium oxalate — few —</td>
<td>Uric acid — few —</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>Few</td>
<td>4</td>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Many</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>1 hyaline</td>
<td>2 coarse granular</td>
<td>Few</td>
<td>16</td>
<td>106</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>Many</td>
<td>Calcium oxalate — few —</td>
</tr>
<tr>
<td>Average</td>
<td>0.2 hyaline</td>
<td>0.4 coarse granular</td>
<td>3.2</td>
<td>21.2</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
<td>Many</td>
<td>Calcium oxalate — few —</td>
<td>Yeast</td>
</tr>
<tr>
<td>Report</td>
<td>0-1 hyaline</td>
<td>0-1 coarse granular</td>
<td>Few</td>
<td>Few</td>
<td>20-30</td>
<td>0-1</td>
<td>0</td>
<td>Occasionally Many (rads)</td>
<td>Calcium oxalate — few —</td>
<td>Yeast</td>
</tr>
</tbody>
</table>

WBC, white blood cells; RBC, red blood cells.

---

**PROCEDURE 52-7**

**Perform Quality Control Measures: Determine the Reliability of Chemical Reagent Strips**

**GOAL**: To reconstitute a control sample and test the reliability of the urinalysis chemical testing strip.

**EQUIPMENT and SUPPLIES**
- Check-Stix Control Strips for Urinalysis (Bayer)
- Distilled water
- Capped tube with milliliter markings
- Test tube rack
- Forceps
- Timer
- Chemical strips for urine testing
- Color chart for chemical strips
- Disposable gloves
- Biohazard waste container

**PROCEDURAL STEPS**

1. Assemble the equipment and supplies. Record the lot number and the expiration date of the Check-Stix.
   **PURPOSE**: Check-Stix cannot be used if they are past the expiration date. Recording the lot number and expiration date is an important part of quality assurance.
2. Sanitize your hands and put on nonsterile gloves.
   **PURPOSE**: To ensure infection control.
3. Place a conical tube in the rack and remove the cap.
4. Pour 15 ml of distilled water into the tube.
5. Using forceps, remove one strip from the bottle. Inspect the strips for mottling or discoloration.
   **PURPOSE**: Mottling or discoloration may mean that the strips have been exposed to moisture, light, or solvents. Improperly stored control strips should not be used.
6. Place the strip in the water and tightly cap the tube.
7. Invert the tube for 2 minutes.
   **PURPOSE**: Chemicals embedded in the pads must be thoroughly dissolved in the water.
8. Allow the tube to sit in the rack for 30 minutes.
9. Invert the tube one time and remove the strip with forceps.
10. Discard the strip in a biohazard waste container. Once reconstituted, the control solution is stable for 8 hours at room temperature.
   **PURPOSE**: To ensure infection control.
11. Perform quality control of the chemical reagent strip by dipping it into the control solution according to Procedure 52-5.
12. Read and record the results.
13. Compare the results to the Check-Stix package insert or chart on the bottle provided by the manufacturer.
   **PURPOSE**: Results should fall within a given range provided by the manufacturer. If they do not, the chemical reagent strips cannot be used to test patients' urine.
14. Discard the chemical reagent strip and the control solution in the biohazard container.
15. Clean up the work area, remove your gloves, and sanitize your hands.
   **PURPOSE**: To ensure infection control.
than glucose also can appear in the urine. Certain metabolic disorders can result in the excretion of sugars such as galactose, fructose, lactose, maltose, or pentoses. Galactosemia, a rare pathologic condition, is a congenital deficiency in the body's ability to metabolize galactose to glucose; galactosemia results in excretion of galactose in the urine. Seen in infants, it results in failure to thrive, vomiting, and diarrhea. If detected early, galactose can be eliminated from the diet, and the child develops normally. Lactose may be found in the urine of pregnant women or premature infants. In rare cases, urine may contain fructose or pentoses (e.g., xylose or arabinose) as a result of excessive consumption of honey or fruit. Maltose may be excreted in patients with diabetes. Of the many sugars, only the presence of glucose or galactose signifies a pathologic condition.

The Clinistix (Bayer), which is based on the chemical reduction of copper, is commonly used to screen and confirm glycosuria and to detect other sugars in urine (Procedure 52-8). Copper reduction tests are based on the principle that reducing substances can chemically convert cupric sulfate to cuprous oxide, resulting in a color change. A sugar's reducing ability is determined by the presence of a "chemical reducing group" present in all monosaccharides. The Clinistix tablet is dropped directly into a test tube containing diluted urine. A heat-releasing reaction occurs, and after the boiling stops, the color of the tube's contents is compared with a chart provided by the manufacturer.

Acetest

Acetest reagent tablets provide an alternative to strip testing when the urine must be tested for the presence of ketones. Ketonuria results when the body metabolizes stored fat because of inadequate cellular uptake of carbohydrates. This is common with diabetes, starvation, and excessive vomiting. The Acetest tablet test (Bayer) is based on the same chemical reaction as the reagent strip test, but its advantage lies in the fact that the tablets can be used with specimens other than urine, and it detects both acetone and acetoacetate.

Urine Pregnancy Testing

The phrase "the rabbit died" came to be a euphemism for a positive pregnancy test in the late 1920s and early 1930s. About 1927, it was discovered that if the urine of a pregnant woman was injected into a rabbit, hemorrhaging occurred in the rabbit's ovaries. These bulging masses could not be seen without killing the rabbit to inspect the ovaries, so invariably, every rabbit died, even if the woman was not pregnant. All pregnancy tests detect the presence of human chorionic gonadotropin (hCG), a hormone produced by the placenta and present in urine during pregnancy. After implantation of the fertilized egg in the uterus, the hCG levels in serum double every few days. This rapid rise occurs for approximately 7 weeks, and then the level begins to decline. Within 72 hours of delivery, the hormone disappears.

Nowadays no rabbits are needed to confirm a pregnancy. The most common type of test for pregnancy is the lateral flow immunoassay test. Many brands are available for laboratory use and are also available over the counter. These tests can be sensitive enough to detect the presence of hCG as early as 1 week after implantation or 4 to 5 days before a missed menstrual period. The tests can be performed in as little as 5 minutes, and the results are easy to interpret, usually as easy as reading a color change. For optimum results, the test should be performed on the first morning voided specimen. The test is based on reactions that occur between antibodies and antigens. Antibodies are proteins formed in response to antigens. When they come in contact, the antibody binds to the antigen, as long as the two are present in sufficient quantity and the antibody is specific for the antigen (e.g., as with a lock and key).

The pregnancy test cartridge contains a membrane with an absorbent pad overlapping a strip of fiberglass paper that is impregnated with a freeze-dried conjugate of gold particles and antibodies to hCG (Figure 52-33). The urine sample is introduced into the device, and it wicks through the absorbent pad, reaching a chromatographic membrane (color-coded reservoir pad). As it contacts the membrane, the urine dissolves the freeze-dried conjugate. In a positive sample, the hCG antigen attaches to the antibodies in the colloidal solution. As the conjugate moves forward on the membrane, anti-hCG monoclonal antibodies affixed on the test zone ("T") bind the hCG-gold conjugate complex, where the gold particles accumulate, forming a pink line. All samples cause the "C" line to turn pink. The "C" line contains antibodies that bind to the colloidal gold conjugate, regardless of whether they have bound to hCG. The presence of this line indicates that the test has been carried out correctly. The QuickVue test is a later flow pregnancy test that can be performed on urine (Procedure 52-9). It is used routinely in many physicians' office laboratories.

CRITICAL THINKING APPLICATION 52-5

Dr. Hill has ordered a routine UA with C&S and a pregnancy test for his patient, and Rosa has instructed the patient in the collection of the specimen. Which laboratory division (or divisions) will be responsible for the testing? Must a separate specimen be collected for each test?

Ovulation Testing

CLIA-waived lateral flow urine tests are available to assist in the prediction of ovulation for women attempting to conceive either naturally or using artificial insemination. During the menstrual cycle, human luteinizing hormone (LH) remains at a relatively stable level. Approximately 14 days before menstruation, the body experiences the "LH surge," a brief, rapid increase in LH. This surge triggers the release of the ovum from the ovary. Two to 3 days after the surge, the LH level returns to the base level. Conception is most likely to occur within 36 hours after the LH surge. The principle of this test is similar to that of the pregnancy test; the reservoir pad contains anti-LH antibodies conjugated to colloidal gold. A positive test result indicates a urine LH level of 20 mIU/mL or higher. Testing usually is performed for 5 consecutive days in the middle of the cycle. Once the surge is detected, ovulation can be expected within 2 to 3 days.

Menopause Testing

A woman is said to have reached menopause when menstruation has not occurred for at least 12 months. The time before meno-
PROCEDURE 52-8

Perform a Urinalysis: Test Urine for Glucose Using the Clinitest Method

GOAL: To perform confirmatory testing for glucose in the urine using the Clinitest procedure for reducing substances.

EQUIPMENT and SUPPLIES
- Urine specimen
- Clinitest tablet, tube, and dropper
- Distilled water
- Test tube rack
- Color chart
- Timer
- Disposable gloves
- Eye protection
- Biohazard waste container
- Patient record

PROCEDURAL STEPS

1. Sanitize your hands and put on nonsterile gloves and eye protection.
2. Holding a Clinitest dropper vertically; add 10 drops of distilled water and then 5 drops of urine to a Clinitest tube.
   PURPOSE: Holding the dropper vertically prevents altering of the size of the drops.
3. Place the prepared tube in the rack (Figure 1).
   PURPOSE: The tube will become too hot to hold when the tablet is placed in the tube.
4. With dry hands remove a Clinitest tablet from the bottle by shaking a tablet into the bottle cap.
   PURPOSE: Clinitest tablets react with moisture and become caustic. Handling tablets with moist hands could result in hydroxide burns.
5. Tap the tablet into the test tube and recap the container.
6. Observe the entire reaction to detect the rapid pass-through phenomenon, which indicates that the glucose level in the urine is very high.
   (See step 9.)
   PURPOSE: If pass-through occurs but is not detected, the reading will be falsely low.
7. When boiling stops, time exactly 15 seconds and then gently shake the tube to mix the entire contents.
8. Immediately compare the color of the specimen with the five-drop color chart and record your findings (Figure 2).
   PURPOSE: Color darkens with time. For accurate results, time carefully.
9. If an orange color briefly develops during the reaction, rapid pass-through has occurred, and the test must be repeated using the two-drop color chart.

10. Record the results.
11. Clean up the work area, remove your gloves, and sanitize your hands.
   PURPOSE: To ensure infection control.
12. Record the results in the patient’s record.
   PURPOSE: A procedure is not considered finished until it is recorded.

pause, called perimenopause, can last for years, bringing with it uncomfortable symptoms such as irregular periods, hot flashes, vaginal dryness, or sleep problems. Some of this may be due to an increase in follicle-stimulating hormone (FSH). Levels of FSH, which is produced by the pituitary gland, increase temporarily each month to stimulate the ovaries. When a woman enters menopause, the ovaries stop producing eggs, and the levels of FSH rise. CLIA-waived lateral flow tests detect FSH in the urine. A positive test result indicates that a woman may be in a state of menopause; a negative test result, along with symptoms of menopause, may indicate a woman is in perimenopause. The qualitative lateral flow test should never be used to direct a woman to stop using birth control methods if she does not want to conceive, because pregnancy is still possible during perimenopause.
PROCEDURE 52-9

Perform a Urinalysis: Perform a Pregnancy Test

GOAL: To perform a pregnancy test on urine using the QuickVue pregnancy test method.

EQUIPMENT and SUPPLIES

- Urine specimen
- QuickVue test kit (Quidel, San Diego, Calif.)
- Disposable gloves
- Biohazard waste container
- Patient's record

PROCEDURAL STEPS

1. Sanitize your hands. Put on nonsterile gloves.
2. Prepare the testing equipment (Figure 1).
3. Collect the specimen.
4. Remove the test cassette from the foil pouch.
5. Add three drops of urine using the dropper that accompanies the kit (Figure 2). Dispose of the dropper in a biohazard bag.
   PURPOSE: To ensure accurate test results, the specimen amount must be exact.
6. Wait 3 minutes and read the test results.
   PURPOSE: To ensure accurate test results, timing must be exact.
7. Interpret the results (Figure 3).
   - Negative: A blue control line is next to the letter C; no line is seen next to the letter T.
   - Positive: A blue control line is next to the letter C, and a pink line is next to the letter T.
8. If a blue line does not appear in the C area, the test is invalid and the specimen must be retested using another kit. Check the expiration date of the kit before proceeding.
9. Discard the cassette in a biohazard waste container, remove your gloves, and sanitize your hands.

   PURPOSE: To ensure infection control.

10. Record the results in the patient's record as either positive or negative.
   PURPOSE: A procedure is not considered finished until it is recorded.

Bladder Tumor-Associated Antigen Testing

The most reliable test for identifying bladder cancer is cystoscopy; however, this is an invasive test. Urine cytology is noninvasive and accurate at detecting high-grade bladder cancer and carcinoma in situ, but its ability to detect low-grade cancer is limited. Therefore, urine-based marker tests have been developed that are noninvasive and accurate at detecting low-grade bladder cancer. In addition, they are useful for monitoring for recurring bladder cancer.

The BTA Stat Test (Bion Diagnostics, Woburn, Massachusetts) is a rapid, single-step immunoassay. The disposable test device, which looks much like the device used for pregnancy testing, contains two monoclonal antibodies that detect the presence of human complement factor H-related protein (HCFHrp), which is shed by cancerous bladder cells but not by normal
bladder epithelial cells. When the BTA Stat Test is used, freshly voided urine is placed in the sample well of the test device, and positive or negative results are provided in 5 minutes. Bladder cancer is one of the most common forms of cancer in the United States. About 53,000 Americans are diagnosed with the disease each year, and approximately 500,000 people are routinely monitored for it. The cancer is most common in men over age 50, smokers, and workers exposed to chemicals in the rubber, leather tanning, metal, and dye industries.

**Critical Thinking Application 52-6**
After centrifugation of the three urine specimens, Rosa prepares to view the sediment. She knows she must correlate the findings from the visual and chemical examinations she has already performed on these specimens. She reviews the results and notes that Mr. Park’s and Mrs. Carpenter’s specimens were clear, but Ms. Hillman’s specimen was turbid. Given the results of the chemical analysis, during which Rosa noted an alkaline pH, an elevated nitrite level, and an elevated leukocyte esterase reading, what might she find when she examines Ms. Hillman’s specimen microscopically?

**Urine Toxicology**
Toxicology is the study of poisonous substances and their effects on the body. The clinical laboratory performs testing on body fluids and tissues to monitor the use of therapeutic drugs such as digoxin (a cardiac medication) or to detect poisonings by herbicides, metals, animal toxins, and poisonous gases (e.g., carbon monoxide).

Laboratory testing for illegal drugs or alcohol also is done, most commonly as an employment, insurance, or legal requirement (Table 52-7). Although serum (blood) tests are more accurate for determining current impairment or the time of ingestion, urine is the specimen of choice for most routine screening procedures. For routine screening, a random specimen usually is collected. Often, safeguards are used to ensure that a specimen is fresh and truly from the patient. Water may be temporarily unavailable in the restroom, and specimens may be added to the toilets. A container with a temperature-sensitive strip may be provided, and someone may accompany the patient into the restroom. In some cases a strict chain of custody is required. The substance for which the test is performed or its metabolite often remains in urine much longer than the impairment or intoxication lasts. This is one reason urine screening is favored over serum or blood screening.

As a medical assistant, you may be responsible for collecting specimens for toxicology tests and for performing certain tests.
Rapid drug screening devices are about the size and shape of a credit card (Figure 52-34). The device is dipped into a urine sample, or urine is directly applied to the device. The results are read according to the manufacturer’s instructions in just minutes. “Negative” results indicate that none of the targeted drugs were detected in the urine sample at specified cutoff levels; “inconclusive” results indicate that the device reacted with something in the urine and confirmation testing is required.

The Instant-View Multi-Drug Screen (Alfa Scientific, Poway, California) urine test is a lateral flow chromatographic immunassay that tests for urine metabolites of a variety of drugs, including amphetamines, barbiturates, benzodiazepines, cocaine, morphine, methadone, phencyclidine (PCP), tricycles, marijuana, Ecstasy, and methamphetamines. Available in cartridges that test from two to six drugs, the test is a competitive binding immunassay in which drug and drug metabolites in a urine sample compete with immobilized drug conjugate for limited labeled antibody binding sites. By using antibodies specific to different drug classes, the test permits independent, simultaneous detection of up to six drugs from a single sample in 5 minutes.

In the procedure, urine mixes with a labeled antibody-dye conjugate and migrates along a porous membrane. If the concentration of a given drug is below the detection limit of the test, the antibody-dye conjugate that did not bind to a drug metabolite binds to antigen conjugate immobilized on the membrane, producing a rose-pink–colored band in the appropriate band for that drug. If the level of the drug in the urine is at or above the detection limit, free drug competes with the immobilized antigen conjugate on the membrane by binding to the antibody-dye conjugate, forming an antigen-antibody complex and preventing the development of a rose-pink band (Procedure 52-10). Note that unlike the lateral flow test for pregnancy, ovulation, and menopause, with a drug screening test, the appearance of a line in the T band indicates a negative test result.

Drug testing has legal ramifications; therefore, additional testing often is necessary to ensure that samples have not been adulterated (Procedure 52-11). Adulteration is the intentional manipulation of a urine sample to falsely pass a drug screening test. It may involve using urine from another person or an animal, diluting the sample with water, or adding substances such as bleach, vinegar, eye drops, baking soda, drain openers, soft drinks, or hydrogen peroxide. Urine collection cups with built-in thermometer panels often are used to ensure that urine has been freshly voided from the bladder. A temperature of 32.2° to 37.7° C (90° to 100° F) within 4 minutes of collection is expected. Test strips that detect human immunoglobulins (antibodies) in urine can determine whether the specimen is human in origin and if it is naturally dilute or has been diluted. Human immunoglobulin G (IgG) is exclusive to humans and is always found at certain levels in urine, even if it is dilute. The addition of chemicals to the urine will prevent the reaction on the test strip.

**BASICS OF DRUG TESTING**

- The individual being tested must provide photo identification.
- Indirect observation of specimen collection is important to make sure the sample is actually provided by the patient being tested. Indirect methods of observation include measuring the specimen’s temperature; securing water faucets in the restroom so that urine cannot be diluted; and having the patient remove outer clothing and leave personal belongings in the examination room.
- Water cannot be run in the restroom during the collection, and the toilet should not be flushed.
- If it is suspected that the sample has been adulterated, the patient can be asked to provide another specimen.
- Immediately after you receive the specimen, check its temperature and volume (30 to 45 mL is required) and inspect it for any indications of adulteration (e.g., an unusual color or the presence of foreign materials).
- Pour the specimen into a specimen bottle and seal the lid with the seal provided at the bottom of the chain of custody form; include the date and your initials on the label (Figure 52-35).
- Ship the specimen to the testing laboratory as soon as possible; it must be sent the same day it is collected.
- Individual results may vary, making some results positive at lower substance levels; also, diet, the volume of urine flow, and the amount of substance used can alter results.
- Because of the legal implications of drug testing, chain of custody must be strictly followed. Each step from collection of the specimen to the report of test results to the patient must be strictly monitored. Requirements include sealed specimen containers; supervised laboratory analysis throughout the process; and authorized signatures at each step.

Other test strips are available that detect creatinine, nitrite, pH, specific gravity, glutaraldehyde, and oxidants. Creatinine is always present in normal urine, because it is excreted from the body at a constant rate. Low or absent levels indicate diluted or substituted nonhuman samples. Urine can be diluted if the person being tested drinks abnormally large amounts of water before the test or if water or another liquid is added to the sample. Creatinine levels usually are checked in conjunction with the specific gravity to screen for dilution or substitution adulteration.
PROCEEDURE 52-10

Perform a Urinalysis and Patient Screening Using Established Protocols: Perform a Multidrug Screening Test on Urine

GOAL: To screen a urine specimen for drugs or drug metabolites at their specified cutoff levels.

EQUIPMENT and SUPPLIES

- Instant-View Multi-Drug Screen Urine Test in a sealed pouch
- Freshly voided urine sample
- Timer
- Biohazard container
- Disposable gloves
- Patient’s record

PROCEDURAL STEPS

1. Sanitize your hands and assemble the equipment and specimen. Check the expiration date on the test kit.
   PURPOSE: An expired test strip may yield inaccurate results.
2. Determine the temperature of the urine (within 4 minutes of voiding). The temperature should be between 32.2° and 37.7° C (90° and 100° F).
   PURPOSE: If the urine temperature is below or above this range, the sample may have been adulterated. Once it has been determined that the sample is at the correct temperature, it may be stored at room temperature for 8 hours or in the refrigerator for up to 3 days before testing.
3. Bring the specimen and the testing device to room temperature.
   PURPOSE: Both the specimen and the device must be at room temperature to ensure accurate results.
4. Remove the device from the foil pouch and label it with the specimen identification.

Dip Method

5. Remove the cap of the specimen and dip the device into the specimen for 10 seconds. The surface of the urine must be above the sample well and below the arrowheads in the window (Figure 1).
   PURPOSE: The pads must be satured with urine.

Alternate Method

6. Remove the pipet from the pouch and fill the pipet to the line on the barrel with urine. Dispense the entire volume onto the sample well on the testing device (Figure 2).
   PURPOSE: If insuffient urine is available in the cup to use the dip method, this method applies urine to the device.
7. Recap the urine specimen.
8. Set the timer for 4 to 7 minutes. Do not reed the results after 7 minutes.
   PURPOSE: Correct timing is essential for reliable, accurate results.
9. Interpet the results (Figure 3):
   - Positive: If the C line appears and there is no T line, the test indicates a positive result for that drug.
   - Negative: If the C line and the T line both appear, the test indicates that the level for the drug or its metabolites is below the cutoff level.
   - Invalid—if no C line develops within 5 minutes on any test strip, the assay is invalid. Make sure the urine has not been adulterated (see Procedure 52-11) and/or repeat the assay with a new test device.

10. Record the results in the patient’s record.
   PURPOSE: A procedure is not considered complete until it is recorded.
11. Color photocopying provides a permanent record of results, but the copy must be made within 7 minutes of adding the urine. Make sure the photocopier does not become contaminated; wipe the glass with alcohol or another manufacturer-approved disinfectant after making the copy.
12. Discard the urine and the device in the biohazard container.
13. Remove your gloves and sanitize your hands.
   PURPOSE: To ensure infection control.
Perform a Urinalysis: Assess a Urine Specimen for Adulteration Before Drug Testing

**GOAL:** To assess a urine specimen for additive adulteration

**EQUIPMENT and SUPPLIES**
- Quick Test Adulterant Strips (Quick Test USA, Boca Raton, Fla.)
- Urine sample (freshly voided; urine should be stored at room temperature for no longer than 2 hours or at refrigerator temperature for no longer than 4 hours before testing)
- Paper towels
- Timer
- Biohazard waste container
- Disposable gloves
- Patient’s record

**PROCEDURAL STEPS**

1. Sanitize your hands and assemble the equipment and the specimen. Check the expiration date on the test kit. 
   **PURPOSE:** An expired test strip may yield inaccurate results.
2. Put on gloves. Remove one strip from the container and recap tightly.
3. Dip the test strip briefly into the urine and then remove it.
4. Blot the strip by touching the side of the strip to a paper towel. 
   **PURPOSE:** Oversaturated strips may not react consistently.
5. Read the results within 1 minute by comparing each pad to the color strips on the canister (Figure 1). 
   **PURPOSE:** Exceeding the allotted time may result in error.
6. Dispose of the paper towels and strip in the biohazard container.
7. Remove your gloves and dispose of them in the biohazard container; sanitize your hands.
   **PURPOSE:** To ensure infection control.
8. Record the results in the patient’s record.
   **PURPOSE:** A procedure is not considered complete until it is recorded.

![](image)

**Figure 1**

*These results are for the Quick Test Adulterant Strips. Because the monitor color may vary from manufacturer to manufacturer, please refer to the package for the specific product for accurate color reference.

Specific gravity readings also determine whether substances such as table salt have been added to the urine.

Nitrites are oxidizing substances that react with the drug or drug metabolite molecules in the urine. Nitrites primarily interfere with antibody binding in lateral flow tests. Nitrites must be added to the urine after voiding. Commercial adulterants, such as Whizzies, Klea, and Urine Luck, are tablets or powders that can be added to voided urine. They do not change the color or temperature of the urine. The level of nitrites found in urine with gross bacteriuria or from therapeutic drug metabolites (e.g., nitroglycerine) is below the cutoff for adulteration screening tests.

The pH of the sample can affect the enzymatic and antibody reactions in the lateral flow drug tests. Levels higher than 9.5 or lower than 3.0 may hamper the enzymatic rate. Alteration of the pH may also affect the stability of the drug or its metabolite. Adulteration of a sample with bleach, drain cleaners, or baking soda changes the pH, but this type of tampering can be detected by an adulteration strip test.

Glutaraldehyde can mask the presence of illegal drugs. Commercially available products such as UrinAid and Clear Choice contain glutaraldehyde intended to adulterate urine. In addition, a 10% solution of glutaraldehyde is sold over the counter for the treatment of warts. The chemical prevents the enzymes in lateral flow tests from reacting properly.

Sensitivity limits for drug screening are set by the U.S. Substance Abuse and Mental Health Services Administration (SAMHSA), the National Institute on Drug Abuse (NIDA), and the U.S. Department of Health and Human Services. Positive results on urine samples tested for substances should be confirmed by more specific chemical methods, such as gas chromatography (GC), mass spectrometry (MS), and enzyme-multiplied immunoassay (EMIT).

**Alcohol Testing**

Alcohol testing is not performed on urine, but CLIA-waived tests are available to detect alcohol using saliva. Saliva-based tests have a high degree of correlation to blood alcohol analysis. The saliva alcohol test manufactured by STC Technologies (Bethlehem, Pennsylvania) uses a Dacron swab saturated with saliva to detect ethanol. The test is used primarily for workplace testing, including the federal mandated testing of transportation workers, but also in private company “drug-free workplace” programs and by emergency departments.

**CULTURING THE URINE**

Urine cultures are performed to assist in the diagnosis of a UTI and to assess the effectiveness of certain antibiotics in the treat-
ment of the infection. Rapid detection systems and culturing of specimens using Petri dishes are addressed in Chapter 55.

### CLOSING COMMENTS

#### Patient Education

Frequently a medical assistant is called on to explain collection techniques to the patient. Patients want to do the procedure correctly but often lack the knowledge of urinary terminology and are embarrassed to or do not know how to ask questions regarding the cleaning of the genital area. When explaining a urinary collection procedure, use pictures and words that the patient will understand. As you explain the procedure in terms that the patient knows, he or she will also feel comfortable in telling you or asking you pertinent details that may have a definite impact on the treatment of the problem. Providing the patient with a clearly written instruction sheet is also helpful. The instruction sheet should be personalized with his or her name, the time to begin collection or testing (if applicable), what supplies should be used, and a phone number to call if questions arise.

### LEGAL AND ETHICAL ISSUES

Like all other procedures, the test is only as valid as the specimen and the procedure performed on that specimen. You, as the physician’s agent, are responsible for that validity when you instruct the patient and when you perform the test.

A medical assistant who is responsible for office laboratory testing must clearly understand the basic concepts of laboratory medicine. To do this, you must stay current with the rapid technological advances in laboratory medicine and assist in establishing a protocol of the tests best suited to your physician-employer.

You have the responsibility for properly collecting specimens and accurately testing them. In addition, you are responsible for strict adherence to protocol when collecting and testing specimens when there are legal ramifications to the test results. Patient confidentiality is paramount when performing drug testing, as is rigid conformation to all established rules and regulations.

### SUMMARY OF SCENARIO

Rosa’s capabilities in the laboratory analysis of urine are highly valued by Dr. Hill. Because tests can be performed in the office laboratory, Dr. Hill has the results immediately. Dr. Hill’s patients also appreciate the convenience of office laboratory testing, in which physical and chemical analysis is performed by Rosa and other medical assistants, and microscopic UA is performed by Dr. Hill. Mrs. Carpenter knows the results of her pregnancy test on her first morning urine without waiting for a call from the laboratory, and urinalysis of Ms. Hillman’s CCMS urine sample will help Dr. Hill diagnose a UTI within minutes. Rosa knows that the laboratory services and quality control measures she takes when performing the complete UA or lateral flow tests are an integral part of the excellent patient care provided by Dr. Hill.

### 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 the 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. Understand the purpose of routine urinalysis. Routine UA is performed primarily as a screening test to detect metabolic and physiologic disorders. Urine is easily obtained, making it an ideal specimen for testing. Urine is analyzed to detect extrinsic and intrinsic pathologic conditions.

4. Describe the physiology of urine formation. Urine is formed through a filtration mechanism in the kidney via the nephrons. As the filtrate passes through the tubules, various changes occur. Urine is stored in the bladder and voided through the urethra.

5. Explain the various means and methods used to collect urine specimens.

Some urine collections, such as the 2-hour postprandial specimen, must be timed around meals or fasts. Routine UA requires no special preparation, whereas a CCMS requires cleansing of the external genitalia. Only urine that will be cultured must be collected in a sterile container. Urine to be sent to a referral laboratory may require the addition of preservatives.

6. Display sensitivity to patients’ rights and feelings when collecting specimens. Requesting a urine specimen from a patient may be an embarrassing moment for the patient. The request should be made in private, and the patient should be given explicit instructions so that he or she understands what is expected.

7. Instruct a patient in the collection of a 24-hour urine specimen. Timed urine specimens are collected to determine the amount of a particular analyte in the urine during a given time frame. Proper patient instruction is necessary to obtain an acceptable specimen (see Procedure 52-1).

8. Instruct a patient in the collection of a clean-catch midstream urine specimen. Proper patient instruction is necessary for an acceptable CCMS. Both men and women are given instructions in cleaning the external genitalia to
prevent contamination of the urine. Urine must be collected in a sterile container and refrigerated if it cannot be tested within 1 hour (see Procedure 52.2).

9. Describe the components of the physical and chemical examination of urine.
   Physical examination of the urine involves determination of the color, turbidity, and specific gravity. Odor and foam color may be noted (see Procedure 52.3). The chemical examination of urine involves determination of the pH level as well as the levels of glucose, protein, ketones, blood, bilirubin, uric acid, and nitrates, specific gravity, and leukocytes by using a reagent strip.

10. Measure the urine specific gravity.
    Refer to Procedure 52.4.

11. Perform a complete urinalysis using a chemical reagent strip.
    A complete UA involves physical, chemical, and microscopic assessment. The results of the three must correlate with one another. Most urine testing requires reagent strips or tablets. It is essential that these supplies be stored in dark, cool, moisture-free areas (see Procedure 52.5).

12. Recognize and correctly identify the formed elements found in a microscopic examination of urine sediment.
    Formed elements in the urine sediment include casts, cells, and crystals. Artifacts may be present but are not reported.

13. Prepare a urine specimen for microscopic examination.
    Refer to Procedure 52.6.

14. Perform quality control measures to determine the reliability of chemical reagent strips.
    Refer to Procedure 52.7.

15. Conduct glucose testing using the Clinitest method.
    The Clinitest detects reducing sugars in the urine, including glucose and galactose. It is superior to the reagent strip test because it detects sugars other than glucose (see Procedure 52.8).

16. Explain the principle of using lateral flow technology in pregnancy testing.
    Pregnancy tests detect hCG, a hormone produced by the placenta. Anti-hCG antibodies embedded in test cartridges bind to hCG and initiate color changes in test areas. Urine moves through lateral flow devices by capillary action.

17. Perform a pregnancy test.
    Refer to Procedure 52.9.

18. Describe methods for determining fertility and menopause using Clinical Laboratory Improvement Amendments (CLIA)-waived urine tests.
    Fertility can be assessed using lateral flow tests that detect LH, a hormone that increases in concentration in the urine shortly before ovulation. Menopause can be assessed using lateral flow tests that detect FSH, which increases as menopause approaches.

19. Explain the principle of lateral flow technology in drug testing on urine.
    Drug testing with lateral flow technology is similar to that for pregnancy testing except that it uses a competitive binding principle. Unlike with the pregnancy test, a line in the T region indicates a negative test.

20. Demonstrate a method of drug testing on a urine specimen.
    Refer to Procedure 52.10.

21. List means by which urine could be adulterated before drug testing.
    Consuming excessive water before urinating, adding water to a urine specimen, and adding chemicals or products sold specifically to adulterate urine all could render a drug test invalid. Adulteration test strips can detect most methods of adulteration.

22. Demonstrate a method of detecting adulterating substances in a urine sample for drug testing.
    Refer to Procedure 52.11.