Objectives

After study of this chapter you should be able to:

1. Label a diagram of the urinary tract and follow the flow of urine through the body.
2. Label a diagram of the kidney.
3. Identify the portions of the nephron and explain how each functions in urine formation.
4. Explain the relationship between the kidney and the blood circulation.
5. Identify and use the roots pertaining to the urinary system.
6. Describe the major disorders of the urinary system.
7. Define medical terms commonly used in reference to the urinary system.
8. Interpret abbreviations used in reference to the urinary system.
9. Analyze several case studies pertaining to urinary disorders.
The urinary system consists of two kidneys, two ureters, the urinary bladder, and a urethra (Fig. 13-1). This system forms and eliminates urine, which contains metabolic waste products. The kidneys, the organs of excretion, also regulate the composition, volume, and acid–base balance (pH) of body fluids. Thus they are of critical importance in maintaining the state of internal balance known as homeostasis. In addition, they produce two substances that act on the circulatory system. Erythropoietin (EPO) is a hormone that stimulates the production of red blood cells in the bone marrow. Renin is an enzyme that functions to raise blood pressure. It does so by activating a blood component called angiotensin, which causes constriction of the blood vessels. The drugs known as ACE inhibitors (angiotensin-converting enzyme inhibitors) lower blood pressure by interfering with the production of angiotensin.
The Kidneys

The kidneys are located behind the peritoneum in the lumbar region. On the top of each kidney rests an adrenal gland. Each kidney is encased in a capsule of fibrous connective tissue overlaid with fat. An outermost layer of connective tissue supports the kidney and anchors it to the body wall.

If you look inside the kidney, you will see that it has an outer region, the renal cortex, and an inner region, the renal medulla (Fig. 13-2). The medulla is divided into triangular sections, each called a pyramid. The pyramids have a lined appearance because they are made up of the loops and collecting tubules of the nephrons, the functional units of the kidney. Each collecting tubule empties into a urine-collecting area called a calyx (from the Latin word meaning “cup”). Several of these smaller minor calyces merge to form a major calyx. The major calyces then unite to form the renal pelvis, the upper funnel-shaped portion of the ureter.

The Nephrons

The tiny working units of the kidneys are the nephrons (Fig. 13-3). Each of these microscopic structures is basically a single tubule coiled and folded into various shapes. At the beginning of the tubule is the cup-shaped Bowman capsule, which is part of the blood-filtering device of the nephron. The tubule then folds into the proximal convoluted tubule, straightens out to form the loop of Henle, coils again into the distal convoluted tubule, and then finally straightens out to form a collecting tubule.

**FIGURE 13-2.** Longitudinal section through the kidney showing its internal structure, and an enlarged diagram of a nephron. There are more than 1 million nephrons in each kidney. (Reprinted with permission from Cohen BJ, Wood DL. Memmler’s The Human Body in Health and Disease. 9th Ed. Philadelphia: Lippincott Williams & Wilkins, 2000.)
**Blood Supply to the Kidney**

Blood enters the kidney through a renal artery, a short branch of the abdominal aorta. This vessel subdivides into smaller vessels as it branches throughout the kidney tissue, until finally blood is brought into the glomerular (Bowman’s) capsule and circulated through a cluster of capillaries, called a *glomerulus*, within the capsule.

Blood leaves the kidney by a series of vessels that finally merge to form the renal vein, which empties into the inferior vena cava.
Urine Formation

As blood flows through the glomerulus, blood pressure forces materials through the glomerular wall and through the wall of the glomerular capsule into the nephron. The fluid that enters the nephron, the **glomerular filtrate**, consists mainly of water, electrolytes, soluble wastes, nutrients, and toxins. The main waste material is **urea**, the nitrogenous (nitrogen-containing) byproduct of protein metabolism. The filtrate should not contain any cells or proteins such as albumin. The waste material and the toxins must be eliminated, but most of the water, electrolytes, and nutrients must be returned to the blood or we would rapidly starve and dehydrate. This return process, termed **tubular reabsorption**, occurs through the peritubular capillaries that surround the nephron. As the filtrate flows through the nephron, other processes further regulate its composition and pH. The concentration of the filtrate is also adjusted under the effects of the pituitary hormone **antidiuretic hormone** (ADH). Finally, the filtrate, now called **urine**, flows into the collecting tubules to be eliminated.

Removal of Urine

Urine is drained from the renal pelvis and carried by the **ureter** to the **urinary bladder** (Fig. 13-4). Urine is stored in the bladder until fullness stimulates a reflex contraction of the bladder muscle and expulsion of urine through the **urethra**. The female urethra is short (4 cm; 1.5 in) and carries only urine. The male urethra is longer (20 cm; 8 in) and carries both urine and semen.

The voiding (release) of urine, technically called **micturition** or **urination**, is regulated by two sphincters (circular muscles) that surround the urethra. The upper sphincter, just below the bladder, functions involuntarily; the lower sphincter is under conscious control.
### Key Terms

#### NORMAL STRUCTURE AND FUNCTION

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antidiuretic hormone (ADH)</td>
<td>A hormone released from the pituitary gland that causes reabsoption of water in the kidneys, thus concentrating the urine</td>
</tr>
<tr>
<td>angiotensin</td>
<td>A substance that increases blood pressure; activated in the blood by renin, an enzyme produced by the kidneys</td>
</tr>
<tr>
<td>calyx</td>
<td>A cuplike cavity in the pelvis of the kidney; also calix (plural, calyces) (root cali, calic)</td>
</tr>
<tr>
<td>erythropoietin (EPO)</td>
<td>A hormone produced by the kidneys that stimulates red blood cell production in the bone marrow</td>
</tr>
<tr>
<td>glomerular capsule</td>
<td>The cup-shaped structure at the beginning of the nephron that surrounds the glomerulus and receives material filtered out of the blood</td>
</tr>
<tr>
<td>glomerular filtrate</td>
<td>The fluid and dissolved materials that filter out of the blood and enter the nephron at the Bowman capsule</td>
</tr>
<tr>
<td>glomerulus</td>
<td>The cluster of capillaries within the glomerular capsule (plural, glomeruli) (root glomerul/o)</td>
</tr>
<tr>
<td>kidney</td>
<td>An organ of excretion (root ren/o, nephr/o); the two kidneys filter the blood and form urine, which contains the waste products of metabolism and other substances as needed to regulate the water and electrolyte balance and the pH of body fluids</td>
</tr>
<tr>
<td>micturition</td>
<td>The voiding of urine; urination</td>
</tr>
<tr>
<td>nephron</td>
<td>A microscopic functional unit of the kidney; working with blood vessels, the nephron filters the blood and balances the composition of urine</td>
</tr>
<tr>
<td>renal cortex</td>
<td>The outer portion of the kidney</td>
</tr>
<tr>
<td>renal medulla</td>
<td>The inner portion of the kidney; contains portions of the nephrons and tubules that transport urine toward the renal pelvis</td>
</tr>
<tr>
<td>renal pelvis</td>
<td>The expanded upper end of the ureter that receives urine from the kidney (root pyel/o, from the Greek word for pelvis, meaning “basin”)</td>
</tr>
<tr>
<td>renal pyramid</td>
<td>A triangular structure in the medulla of the kidney composed of the loops and collecting tubules of the nephrons</td>
</tr>
<tr>
<td>renin</td>
<td>An enzyme produced by the kidneys that activates angiotensin in the blood</td>
</tr>
</tbody>
</table>
**Normal Structure and Function, continued**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>tubular reabsorption</td>
<td>The return of substances from the glomerular filtrate to the blood through the peritubular capillaries</td>
</tr>
<tr>
<td>urea</td>
<td>The main nitrogenous (nitrogen-containing) waste product in the urine</td>
</tr>
<tr>
<td>ureter</td>
<td>The tube that carries urine from the kidney to the bladder (root ureter/o)</td>
</tr>
<tr>
<td>urethra</td>
<td>The tube that carries urine from the bladder to the outside of the body (root urethr/o)</td>
</tr>
<tr>
<td>urinary bladder</td>
<td>The organ that stores and eliminates urine excreted by the kidneys (root cyst/o, vesic/o)</td>
</tr>
<tr>
<td>urination</td>
<td>The voiding of urine; micturition</td>
</tr>
<tr>
<td>urine</td>
<td>The fluid excreted by the kidneys. It consists of water, electrolytes, urea, other metabolic wastes, and pigment. A variety of other substances may appear in urine in cases of disease (root ur/o).</td>
</tr>
</tbody>
</table>

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**Box 13-1 Words That Serve Double Duty**

Some words appear in more than one body system to represent different structures. The medulla of the kidney is the inner portion of the organ. Other organs, such as the adrenal gland, ovary, and lymph nodes, may also be divided into a central medulla and outer cortex. But medulla means “marrow,” and this term is also applied to the bone marrow, to the spinal cord, and to the part of the brain that connects with the spinal cord, the medulla oblongata.

A ventricle is a chamber. There are ventricles in the brain and in the heart. The word *fundus* means the back part or base of an organ. The uterus has a fundus, the upper rounded portion farthest from the cervix, and so does the stomach. The fundus of the eye, examined for signs of diabetes and glaucoma, is the innermost layer where the retina is located. A macula is a spot. There is a macula in the eye, which is the point of sharpest vision. There is also a macula in the ear, which contains receptors for equilibrium.

In interpreting medical terminology, it is often important to know the context in which a word is used.
Roots Pertaining to the Urinary System

### Table 13-1 Roots for the Kidney

<table>
<thead>
<tr>
<th>ROOT</th>
<th>MEANING</th>
<th>EXAMPLE</th>
<th>DEFINITION OF EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ren/o</td>
<td>kidney</td>
<td>infrarenal</td>
<td>below the kidney</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in-fra-RĒ-nal</td>
<td></td>
</tr>
<tr>
<td>nephr/o</td>
<td>kidney</td>
<td>nephrosis</td>
<td>any noninflammatory disease condition of the kidney</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nef-RŌ-sis</td>
<td></td>
</tr>
<tr>
<td>glomerul/o</td>
<td>glomerulus</td>
<td>juxtaglomerular</td>
<td>near the glomerulus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>jucks-ta-glŌ-MER-ū-lar</td>
<td></td>
</tr>
<tr>
<td>pyel/o</td>
<td>renal pelvis</td>
<td>pyeloplasty</td>
<td>plastic repair of the renal pelvis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pī-e-lo-PLAS-tē</td>
<td></td>
</tr>
<tr>
<td>cali-, calic-</td>
<td>calyx</td>
<td>calicectasis</td>
<td>dilatation of a renal calyx</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kal-i-SEK-ta-sis</td>
<td></td>
</tr>
</tbody>
</table>

### Exercise 13-1

Use the root ren/o to write a word that has the same meaning as each of the following definitions:

1. near (para-) the kidney  __________ pararenal __________
2. above (supra-) the kidney  __________
3. between the kidneys  __________
4. around the kidneys  __________
5. behind (post-) the kidney  __________

Use the root nephr/o to write a word that has the same meaning as each of the following definitions:

6. inflammation of the kidney  __________
7. any disease of the kidney  __________
8. softening of the kidney  __________
9. surgical removal of the kidney  __________
10. study of the kidney  __________

Use the appropriate root to write a word that has the same meaning for each of the following definitions:

11. inflammation of a glomerulus  __________
12. excision of a renal calyx  __________
13. radiograph of the renal pelvis  __________
14. dilatation of the renal pelvis  __________
15. hardening of a glomerulus
16. radiographic study (-graphy) of the kidney
17. inflammation of the renal pelvis and kidney

| TABLE 13-2 Roots for the Urinary Tract (Except the Kidney) |
|-----------------|-----------------|-----------------|
| ROOT | MEANING | EXAMPLE | DEFINITION OF EXAMPLE |
| ur/o | urine, urinary tract | urosepsis | generalized infection that originates in the urinary tract |
| urin/o | urine | urination | discharge of urine |
| ureter/o | ureter | ureterostenosis | narrowing of the ureter |
| cyst/o | urinary bladder | cystotomy | incision of the bladder |
| vesic/o | urinary bladder | intravesical | within the urinary bladder |
| urethr/o | urethra | urethroscopy | endoscopic examination of the urethra |

Exercise 13-2

Use the root ur/o to write a word that has the same meaning as each of the following definitions:

1. radiography of the urinary tract
2. a urinary calculus (stone)
3. study of the urinary tract
4. presence of urinary waste products in the blood (-emia)

The root ur/o- is used in the suffix -uria, which means “condition of urine or of urination.” Use -uria to write a word that has the same meaning as each of the following definitions:

5. presence of proteins in the urine
6. lack of urine
7. formation of excess (poly-) urine
8. painful or difficult urination
9. presence of pus in the urine
10. presence of cells in the urine
11. presence of blood (hemat/o) in the urine
12. urination during the night (noct/i)
The suffix -uresis means “urination.” Use -uria to write a word that has the same meaning as each of the following definitions:

13. increased excretion of urine

14. lack of urination

15. excretion of sodium (natri-) in the urine

16. excretion of potassium (kali-) in the urine

The adjective endings for the above words is -uretic, as in diuretic (pertaining to diuresis) and natriuretic (pertaining to the excretion of sodium in the urine). Fill in the blanks:

17. Urinalysis (ū-ri-NAL-i-sis) is the laboratory study of ________________________________.

18. Hydroureter (hī-drö-ū-ŘE-ter) is fluid distension of a(n) ________________________________.

19. A urethrotome (ū-ŘE-thrö-tōm) is an instrument for cutting the ________________________________.

20. The word cystic (SIS-tik), as applied to the urinary system, pertains to the ________________________________.

21. The word vesical (VES-i-kal) pertains to the ________________________________.

Use the appropriate root to write a word for each of the following definitions:

22. inflammation of the urethra

23. a ureteral calculus

24. surgical creation of an opening in the ureter

25. surgical fixation of the urethra

Use the root cysto/o to write a word that has the same meaning as each of the following definitions:

26. inflammation of the urinary bladder

27. surgical fixation of the urinary bladder

28. an instrument for examining the inside of the bladder

29. hernia of the bladder

Use the root vesic/o to write a word that has the same meaning as each of the following definitions:

30. in front of (pre-) the bladder

31. pertaining to the urethra and bladder

Define each of the following terms:

32. transurethral (trans-ū-ŘE-thral)

33. cystostomy (sis-TOS-tō-mē)

34. ureterotomy (ū-řē-ter-OT-ō-mē)

35. cystalgia (sis-TAL-jē-a)

36. uropoiesis (ū-rō-pay-Ē-sis)
Clinical Aspects of the Urinary System

Infections

Organisms that infect the urinary tract generally enter through the urethra and ascend toward the bladder. Although urinary tract infections (UTIs) do occur in males, they appear more commonly in females. Infection of the urinary bladder produces cystitis. The infecting organisms are usually colon bacteria carried in feces, particularly Escherichia coli. Cystitis is more common in females than in males because the female urethra is shorter than the male urethra and the opening is closer to the anus. Poor toilet habits and urinary stasis are contributing factors. In the hospital, UTIs may result from procedures involving the urinary system, especially catheterization, in which a tube is inserted into the bladder to withdraw urine. Less frequently, UTIs originate in the blood and descend through the urinary system.

An infection that involves the kidney and renal pelvis is termed pyelonephritis. As in cystitis, signs of this condition include dysuria, painful or difficult urination, and the presence of bacteria and pus in the urine, bacteriuria and pyuria, respectively.

Urethritis is inflammation of the urethra, generally associated with sexually transmitted diseases such as gonorrhea and chlamydial infections (see Chapter 14).

Glomerulonephritis

Although the name simply means inflammation of the kidney and glomeruli, glomerulonephritis is a specific disorder that occurs after an immunologic reaction. It is usually a response to infection in another system, commonly a streptococcal infection of the respiratory tract or a skin infection. It may also accompany autoimmune diseases such as lupus erythematosus. The symptoms are hypertension, edema, and oliguria, the passage of small amounts of urine. This urine is highly concentrated. Because of damage to kidney tissue, blood and proteins escape into the nephrons, causing hematuria, blood in the urine, and proteinuria, protein in the urine. Blood cells may also form into small molds of the kidney tubule, called casts, which can be found in the urine.

Most patients recover fully from glomerulonephritis, but in some cases, especially among the elderly, the disorder may lead to chronic renal failure (CRF) or end-stage renal disease (ESRD). In such cases, urea and other nitrogen-containing compounds accumulate in the blood, a condition termed uremia. These compounds affect the central nervous system, causing irritability, loss of appetite, stupor, and other symptoms. There is also electrolyte imbalance and acidosis.

![FIGURE 13-5. An indwelling (Foley) catheter in place in the female bladder.](image)
Acute Renal Failure

Injury, shock, exposure to toxins, infections, and other renal disorders may cause damage to the nephrons, resulting in acute renal failure (ARF). There is rapid loss of kidney function with oliguria and accumulation of nitrogenous wastes in the blood. Failure of the kidneys to eliminate potassium leads to hyperkalemia, along with other electrolyte imbalances and acidosis. When destruction (necrosis) of kidney tubules is involved, the condition may be referred to as acute tubular necrosis (ATN).

Renal failure may lead to a need for kidney dialysis or, ultimately, renal transplantation. Dialysis refers to the movement of substances across a semipermeable membrane; it is a method used for removing harmful or unnecessary substances from the body when the kidneys are impaired or have been removed (Fig. 13-6). In hemodialysis, blood is cleansed by passage over a membrane surrounded by fluid (dialysate) that draws out unwanted substances. In peritoneal dialysis, fluid is introduced into the peritoneal cavity. The fluid is periodically withdrawn along with waste products and replaced (Fig. 13-7). The exchange may be done at intervals throughout the day in continuous ambulatory peritoneal dialysis (CAPD) or during the night in continuous cyclic peritoneal dialysis (CCPD).

Urinary Stones

Urinary lithiasis (condition of having stones) may be related to infection, irritation, diet, or hormone imbalances that lead to an increased level of calcium in the blood. Most urinary stones, or calculi, are formed of calcium salts, but they may be composed of other materials as well. Causes of stone formation include dehydration, infection, abnormal pH of urine, urinary stasis, and metabolic imbalances. The stones generally form in the kidney and may move to the bladder (Fig. 13-8). This results in great pain, termed renal colic, and obstruction that can promote infection and cause hydronephrosis (collection of urine in the renal pelvis). Because they are radiopaque, stones can usually be seen on simple radiographs of the abdomen. Stones may dissolve and pass out of the body on their own. If not, they may be removed surgically, in a lithotomy, or by

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**FIGURE 13-6.** Schematic diagram of a hemodialysis system. A cellophane membrane separates the blood compartment and dialysis solution compartment. This membrane is porous enough to allow all of the constituents except the plasma proteins and blood cells to diffuse between the two compartments. (Reprinted with permission from Porth CM. Pathophysiology: Concepts in Altered Health States. 6th Ed. Philadelphia: Lippincott Williams & Wilkins, 2002.)
**FIGURE 13-7.** Peritoneal dialysis. A semipermeable membrane richly supplied with small blood vessels lines the peritoneal cavity. With dialysate dwelling in the peritoneal cavity, waste products diffuse from the network of blood vessels into the dialysate.

**FIGURE 13-8.** Various sites of calculus formation in the urinary tract.
using an endoscope. External shock waves are used to crush stones in the urinary tract in a procedure called extracorporeal (outside the body) shock wave **lithotripsy** (crushing of stones).

**Cancer**

Carcinoma of the bladder has been linked to occupational exposure to chemicals, parasitic infections, and cigarette smoking. A key symptom is sudden, painless hematuria. Often the cancer can be seen by viewing the lining of the bladder with a **cystoscope** (Fig. 13-9). This instrument can also be used to biopsy tissue for study. If treatment is not effective in permanently removing the tumor, a **cystectomy** (removal of the bladder) may be necessary. In this case, the ureters must be vented elsewhere, such as directly to the surface of the body through the ileum in an **ileal conduit** (Fig. 13-10), or to some other portion of the intestine.

Cancer may also involve the kidney and renal pelvis. Additional means for diagnosing cancer and other disorders of the urinary tract include ultrasound, computed tomography scans, and radiographic studies such as **intravenous urography** (Fig. 13-11), also called **intravenous pyelography**, and **retrograde pyelography**.

**Urinalysis**

Urinalysis (UA) is a simple and widely used method for diagnosing disorders of the urinary tract. It may also reveal disturbances in other systems when abnormal byproducts are eliminated in the urine. In a routine urinalysis, the urine is grossly examined for color and turbidity (a sign of bacteria); **specific gravity** (a measure of concentration) and pH are recorded; tests are performed for chemical components such as glucose, ketones, and hemoglobin; and the urine is examined microscopically for cells, crystals, or casts. In more detailed tests, drugs, enzymes, hormones, and other metabolites may be analyzed and bacterial cultures may be performed.

**FIGURE 13-9.** Cystoscopy. A lighted cystoscope is introduced into the bladder of a male subject. Sterile fluid is used to inflate the bladder.
FIGURE 13-10. Ileal conduit.

## Key Clinical Terms

### DISORDERS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>acidosis</td>
<td>Excessive acidity of body fluids</td>
</tr>
<tr>
<td>bacteriuria</td>
<td>Presence of bacteria in the urine</td>
</tr>
<tr>
<td>cast</td>
<td>A solid mold of a renal tubule found in the urine</td>
</tr>
<tr>
<td>cystitis</td>
<td>Inflammation of the urinary bladder, usually as a result of infection</td>
</tr>
<tr>
<td>dysuria</td>
<td>Painful or difficult urination</td>
</tr>
<tr>
<td>glomerulonephritis</td>
<td>Inflammation of the kidney primarily involving the glomeruli. The acute form usually occurs after an infection elsewhere in the body; the chronic form varies in cause and usually leads to renal failure.</td>
</tr>
<tr>
<td>hematuria</td>
<td>Presence of blood in the urine</td>
</tr>
<tr>
<td>hydronephrosis</td>
<td>Collection of urine in the renal pelvis caused by obstruction; causes distention and atrophy of renal tissue. Also called nephrohydronephrosis.</td>
</tr>
<tr>
<td>hyperkalemia</td>
<td>Excess amount of potassium in the blood</td>
</tr>
<tr>
<td>oliguria</td>
<td>Elimination of small amounts of urine</td>
</tr>
<tr>
<td>proteinuria</td>
<td>Presence of protein, mainly albumin, in the urine</td>
</tr>
<tr>
<td>pyelonephritis</td>
<td>Inflammation of the renal pelvis and kidney, usually as a result of infection</td>
</tr>
<tr>
<td>pyuria</td>
<td>Presence of pus in the urine</td>
</tr>
<tr>
<td>renal colic</td>
<td>Radiating pain in the region of the kidney associated with the passage of a stone</td>
</tr>
<tr>
<td>uremia</td>
<td>Presence in the blood of toxic levels of nitrogen-containing substances, mainly urea, as a result of renal insufficiency</td>
</tr>
<tr>
<td>urethritis</td>
<td>Inflammation of the urethra, usually as a result of infection</td>
</tr>
<tr>
<td>urinary stasis</td>
<td>Stoppage or stagnation of the flow of urine</td>
</tr>
</tbody>
</table>

### DIAGNOSIS AND TREATMENT

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>catheterization</td>
<td>Introduction of a tube into a passage, such as through the urethra into the bladder for withdrawal of urine</td>
</tr>
</tbody>
</table>
### Diagnosis and Treatment, continued

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>cystoscopy</strong></td>
<td>An instrument for examining the inside of the urinary bladder. Also used for removing foreign objects, for surgery, and for other forms of treatment.</td>
</tr>
<tr>
<td><strong>dialysis</strong></td>
<td>Separation of substances by passage through a semipermeable membrane. Dialysis is used to rid the body of unwanted substances when the kidneys are impaired or missing. The two forms of dialysis are hemodialysis and peritoneal dialysis.</td>
</tr>
<tr>
<td><strong>hemodialysis</strong></td>
<td>Removal of unwanted substances from the blood by passage through a semipermeable membrane.</td>
</tr>
<tr>
<td><strong>intravenous</strong></td>
<td><strong>pyelography</strong> (IVP) Intraoperative urography</td>
</tr>
<tr>
<td></td>
<td><strong>pyelography</strong> (IVU) Radiographic visualization of the urinary tract after intravenous administration of a contrast medium that is excreted in the urine; also called excretory urography or intravenous pyelography, although the latter is less accurate because the procedure shows more than just the renal pelvis</td>
</tr>
<tr>
<td><strong>lithotripsy</strong></td>
<td>Crushing of a stone</td>
</tr>
<tr>
<td><strong>peritoneal dialysis</strong></td>
<td>Removal of unwanted substances from the body by introduction of a dialyzing fluid into the peritoneal cavity followed by removal of the fluid</td>
</tr>
<tr>
<td><strong>retrograde</strong></td>
<td><strong>pyelography</strong> Pyelography in which the contrast medium is injected into the kidneys from below, by way of the ureters</td>
</tr>
<tr>
<td><strong>specific</strong></td>
<td><strong>gravity</strong> (SG) The weight of a substance compared with the weight of an equal volume of water. The specific gravity of normal urine ranges from 1.015 to 1.025. This value may increase or decrease in disease.</td>
</tr>
<tr>
<td><strong>urinalysis</strong></td>
<td>Laboratory study of the urine. Physical and chemical properties and microscopic appearance are included.</td>
</tr>
</tbody>
</table>

### SURGERY

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>cystectomy</strong></td>
<td>Surgical removal of all or part of the urinary bladder.</td>
</tr>
<tr>
<td><strong>ileal conduit</strong></td>
<td>Diversion of urine by connection of the ureters to an isolated segment of the ileum. One end of the segment is sealed, and the other drains through an opening in the abdominal wall (see Fig. 13-10).</td>
</tr>
<tr>
<td><strong>lithotripsy</strong></td>
<td>Incision of an organ to remove a stone (calculus)</td>
</tr>
<tr>
<td><strong>renal transplantation</strong></td>
<td>Surgical implantation of a donor kidney into a patient</td>
</tr>
</tbody>
</table>
### Supplementary Terms

#### NORMAL STRUCTURE AND FUNCTION

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aldosterone</strong></td>
<td>A hormone secreted by the adrenal gland that regulates electrolyte</td>
</tr>
<tr>
<td></td>
<td>excretion by the kidneys</td>
</tr>
<tr>
<td><strong>Clearance</strong></td>
<td>The volume of plasma that can be cleared of a substance by the kidneys</td>
</tr>
<tr>
<td></td>
<td>per unit of time; renal plasma clearance</td>
</tr>
<tr>
<td><strong>Creatinine</strong></td>
<td>A nitrogen-containing byproduct of muscle metabolism. An increase</td>
</tr>
<tr>
<td></td>
<td>in creatinine in the blood is a sign of renal failure.</td>
</tr>
<tr>
<td><strong>Detrusor Muscle</strong></td>
<td>The muscle in the bladder wall</td>
</tr>
<tr>
<td><strong>Diuresis</strong></td>
<td>Increased excretion of urine</td>
</tr>
<tr>
<td><strong>Glomerular Filtration Rate</strong></td>
<td>The amount of filtrate formed per minute by the nephrons of both kidneys</td>
</tr>
<tr>
<td><strong>Maximal Transport Capacity</strong></td>
<td>The maximum rate at which a given substance can be transported</td>
</tr>
<tr>
<td></td>
<td>across the renal tubule; tubular maximum</td>
</tr>
<tr>
<td><strong>Renal Corpuscle</strong></td>
<td>The glomerular capsule and the glomerulus considered as a unit; the</td>
</tr>
<tr>
<td></td>
<td>filtration device of the kidney</td>
</tr>
<tr>
<td><strong>Trigonе</strong></td>
<td>A triangle at the base of the bladder formed by the openings of the</td>
</tr>
<tr>
<td></td>
<td>two ureters and the urethra (see Fig. 13-4)</td>
</tr>
</tbody>
</table>

#### SYMPTOMS AND CONDITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anuresis</strong></td>
<td>Lack of urination</td>
</tr>
<tr>
<td><strong>Anuria</strong></td>
<td>Lack of urine formation</td>
</tr>
<tr>
<td><strong>Azotemia</strong></td>
<td>Presence of an increased amount of nitrogenous waste, especially</td>
</tr>
<tr>
<td></td>
<td>urea, in the blood</td>
</tr>
<tr>
<td><strong>Azoturia</strong></td>
<td>Presence of an increased amount of nitrogen-containing compounds,</td>
</tr>
<tr>
<td></td>
<td>especially urea, in the urine</td>
</tr>
<tr>
<td><strong>Cystocele</strong></td>
<td>Herniation of the bladder into the vagina (see Fig. 15-17); vesicocele</td>
</tr>
<tr>
<td><strong>Dehydration</strong></td>
<td>Excessive loss of body fluids</td>
</tr>
<tr>
<td><strong>Diabetes Insipidus</strong></td>
<td>A condition caused by inadequate production of antidiuretic hormone</td>
</tr>
<tr>
<td></td>
<td>resulting in excessive excretion of dilute urine and extreme thirst</td>
</tr>
<tr>
<td><strong>Enuresis</strong></td>
<td>Involuntary urination, usually at night; bed-wetting</td>
</tr>
</tbody>
</table>
### Symptoms and Conditions, continued

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>epispadias</td>
<td>A congenital condition in which the urethra opens on the dorsal surface of the penis as a groove or cleft; anaspadias</td>
</tr>
<tr>
<td>glycosuria</td>
<td>Presence of glucose in the urine, as in cases of diabetes mellitus</td>
</tr>
<tr>
<td>horseshoe kidney</td>
<td>A congenital union of the lower poles of the kidneys, resulting in a horseshoe-shaped organ (Fig. 13-12)</td>
</tr>
<tr>
<td>hydroureter</td>
<td>Distention of the ureter with urine caused by obstruction</td>
</tr>
<tr>
<td>hypoproteinemia</td>
<td>Decreased amount of protein in the blood; may result from loss of protein because of kidney damage</td>
</tr>
<tr>
<td>hypospadias</td>
<td>A congenital condition in which the urethra opens on the undersurface of the penis or into the vagina (Fig. 13-13)</td>
</tr>
<tr>
<td>hypovolemia</td>
<td>A decrease in blood volume</td>
</tr>
<tr>
<td>incontinence</td>
<td>Inability to retain urine. Incontinence may originate with a neurologic disorder, trauma to the spinal cord, weakness of the pelvic muscles, urinary retention, or impaired bladder function. Term also applies to inability to retain semen or feces.</td>
</tr>
<tr>
<td>neurogenic bladder</td>
<td>Any bladder dysfunction that results from a central nervous system lesion</td>
</tr>
<tr>
<td>nocturia</td>
<td>Excessive urination at night (noct/o means “night”)</td>
</tr>
<tr>
<td>pitting edema</td>
<td>Edema in which the skin, when pressed firmly with the finger, will maintain the depression produced</td>
</tr>
<tr>
<td>polycystic kidney disease</td>
<td>A hereditary condition in which the kidneys are enlarged and contain many cysts</td>
</tr>
<tr>
<td>polydipsia</td>
<td>Excessive thirst</td>
</tr>
<tr>
<td>polyuria</td>
<td>Elimination of large amounts of urine, as in diabetes mellitus</td>
</tr>
<tr>
<td>retention of urine</td>
<td>Accumulation of urine in the bladder because of an inability to urinate</td>
</tr>
<tr>
<td>staghorn calculus</td>
<td>A kidney stone that fills the renal pelvis and calyces to give a “staghorn” appearance (Fig. 13-14)</td>
</tr>
<tr>
<td>ureterocele</td>
<td>A cystlike dilation of the ureter near its opening into the bladder. Usually results from a congenital narrowing of the ureteral opening (Fig. 13-15).</td>
</tr>
<tr>
<td>urinary frequency</td>
<td>A need to urinate often without an increase in average output</td>
</tr>
<tr>
<td>urinary urgency</td>
<td>Sudden need to urinate</td>
</tr>
</tbody>
</table>
### Symptoms and Conditions, continued

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>water intoxication</td>
<td>Excess intake or retention of water with decrease in sodium concentration. May result from excess drinking, excess ADH, or replacement of a large amount of body fluid with pure water. Causes an imbalance in the cellular environment with edema and other disturbances.</td>
</tr>
<tr>
<td>Wilms tumor</td>
<td>A malignant tumor of the kidney that usually appears in children before the age of 5 years</td>
</tr>
</tbody>
</table>

### Diagnosis

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>anion gap</td>
<td>A measure of electrolyte imbalance</td>
</tr>
<tr>
<td>blood urea nitrogen (BUN)</td>
<td>Nitrogen in the blood in the form of urea. An increase in BUN indicates an increase in nitrogenous waste products in the blood and renal failure.</td>
</tr>
<tr>
<td>clean-catch specimen</td>
<td>A urine sample obtained after thorough cleansing of the urethral opening and collected in midstream to minimize the chance of contamination</td>
</tr>
<tr>
<td>cystometrography</td>
<td>A study of bladder function in which the bladder is filled with fluid or air and the pressure exerted by the bladder muscle at varying degrees of filling is measured. The tracing recorded is a cystometrogram.</td>
</tr>
<tr>
<td>protein electrophoresis (PEP)</td>
<td>Laboratory study of the proteins in urine; used to diagnose multiple myeloma, systemic lupus erythematosus, lymphoid tumor</td>
</tr>
<tr>
<td>urinometer</td>
<td>Device for measuring the specific gravity of urine</td>
</tr>
</tbody>
</table>

### Treatment

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>diuretic</td>
<td>A substance that increases the excretion of urine; pertaining to diuresis</td>
</tr>
<tr>
<td>indwelling Foley catheter</td>
<td>A urinary tract catheter with a balloon at one end that prevents the catheter from leaving the bladder (see Fig. 13-5)</td>
</tr>
<tr>
<td>lithotrite</td>
<td>Instrument for crushing a bladder stone</td>
</tr>
</tbody>
</table>
FIGURE 13-12. Horseshoe kidney. The kidneys are fused at the poles. (Reprinted with permission from Rubin E, Farber JL. Pathology. 3rd Ed. Philadelphia: Lippincott Williams & Wilkins, 1999.)


FIGURE 13-15. Ureterocele. The ureter bulges into the bladder with resultant hydroureter and hydronephrosis.

<table>
<thead>
<tr>
<th>ABBREVIATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADH</td>
</tr>
<tr>
<td>ARF</td>
</tr>
<tr>
<td>ATN</td>
</tr>
<tr>
<td>BUN</td>
</tr>
<tr>
<td>CAPD</td>
</tr>
<tr>
<td>CCPD</td>
</tr>
<tr>
<td>CMG</td>
</tr>
<tr>
<td>CRF</td>
</tr>
<tr>
<td>EPO</td>
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<td>ESRD</td>
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<td>ESWL</td>
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<td>GFR</td>
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<td>GU</td>
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<tr>
<td>IVP</td>
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<td>IVU</td>
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<td>K</td>
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<td>KUB</td>
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<tr>
<td>Na</td>
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<tr>
<td>PEP</td>
</tr>
<tr>
<td>SG</td>
</tr>
<tr>
<td>Tm</td>
</tr>
<tr>
<td>UA</td>
</tr>
<tr>
<td>UTI</td>
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</tbody>
</table>
Labeling Exercise 13-1

Urinary System, With Blood Vessels
Write the name of each numbered part on the corresponding line of the answer sheet.

1. ____________________________  8. ____________________________
2. ____________________________  9. ____________________________
3. ____________________________ 10. ____________________________
4. ____________________________ 11. ____________________________
5. ____________________________ 12. ____________________________
6. ____________________________ 13. ____________________________
7. ____________________________
Longitudinal Section Through the Kidney
Write the name of each numbered part on the corresponding line of the answer sheet.

1. Calyx
2. Pyramids of medulla
3. Renal capsule
4. Renal medulla
5. Renal pelvis
6. Renal cortex
7. Ureter

1. __________________________
2. __________________________
3. __________________________
4. __________________________
5. __________________________
6. __________________________
7. __________________________
Labeling Exercise 13-3

Interior of the Urinary Bladder
Write the name of each numbered part on the corresponding line of the answer sheet.

1. External sphincter
2. Internal sphincter
3. Openings of ureters
4. Prostate
5. Rugae
6. Smooth muscle
7. Trigone
8. Ureter
9. Urethra
10. Urogenital diaphragm
Chapter Review 13-1

Match the following terms and write the appropriate letter to the left of each number:

_____ 1. albuminuria a. abnormal color of urine
_____ 2. pyuria b. pus in the urine
_____ 3. chromaturia c. elimination of small amounts of urine
_____ 4. oliguria d. cells in the urine
_____ 5. cyturia e. proteinuria

_____ 6. adrenal a. pertaining to the blood vessels of the kidneys
_____ 7. intrarenal b. within the kidneys
_____ 8. prerenal c. pertaining to the liver and kidneys
_____ 9. renovascular d. before or in front of the kidneys
_____ 10. hepatorenal e. near the kidney

_____ 11. nocturia a. excretion of potassium in the urine
_____ 12. erythropoietin b. deficiency of urine
_____ 13. uropenia c. excessive urination during the night
_____ 14. kaliuresis d. enzyme that increases blood pressure
_____ 15. renin e. hormone that stimulates red cell production

_____ 16. micturition a. congenital absence of the bladder
_____ 17. acystia b. urination
_____ 18. stasis c. introduction of a tube
_____ 19. catheterization d. incision to remove a stone
_____ 20. lithotomy e. stagnation, as of urine

SUPPLEMENTARY TERMS

_____ 21. trigone a. presence of nitrogenous waste in the urine
_____ 22. azoturia b. excessive thirst
_____ 23. enuresis c. bed-wetting
_____ 24. glycosuria d. triangular area in the base of the bladder
_____ 25. polydipsia e. presence of glucose in the urine
26. creatinine  
27. diabetes insipidus  
28. epispadias  
29. incontinence  
30. diuretic

Fill in the blanks:

31. A microscopic working unit of the kidney is called a(n) ________________________.
32. The cluster of capillaries within the glomerular capsule is the ________________________.
33. The inner portion of the kidney is the ________________________.
34. Laboratory study of the urine is a(n) ________________________.
35. The tube that carries urine from the kidney to the bladder is the ________________________.
36. The main nitrogenous waste product in urine is ________________________.
37. A solid mold of the renal tubule found in the urine is a(n) ________________________.

Define each of the following words:

38. reniform (REN-i-form) ________________________
39. nephrotropic (nef-ro-TROP-ik) ________________________
40. juxtaglomerular (juks-ta-glō-MER-ū-lar) ________________________
41. urethritis (ū-rē-THRI-tis) ________________________
42. caliceal (kal-i-SE-al) (note addition of e) ________________________
43. urethrostenosis (ū-rē-thro-ste-NO-sis) ________________________
44. dysuria (dis-ū-rē-a) ________________________

Word building. Write a word for each of the following definitions:

45. any disease of the kidney (nephr/o) ________________________
46. radiograph of the bladder (cyst/o) and urethra ________________________
47. incision of the bladder (cyst/o) ________________________
48. inflammation of the urinary bladder ________________________
49. inflammation of the renal pelvis and the kidney ________________________
50. surgical removal of a kidney (nephr/o) ________________________
51. plastic repair of a ureter and renal pelvis ________________________
52. surgical creation of an opening between a ureter and the sigmoid colon ________________________
53. dilatation of the renal pelvis and calices ________________________

Opposites. Write a word that has the opposite meaning of each of the following words:

54. hydration ________________________
55. hypovolemia ________________________
56. diuretic
57. hypernatremia
58. uresis

Adjectives. Write the adjective form of each of the following words:
59. vesica (bladder)
60. urology
61. uremia
62. diuresis
63. calyx
64. nephrosis
65. ureter
66. urethra

Plurals. Write the plural form of each of the following words:
67. glomerulus
68. calyx
69. pelvis

Write the meaning of each of the following abbreviations:
70. IVP
71. ADH
72. EPO
73. BUN
74. UTI
75. GFR
76. UA

Word analysis. Define each of the following words, and give the meaning of the word parts in each. Use a dictionary if necessary.
77. cystometrography (sis-tō-me-TROG-ra-fē) 
   a. cyst/o
   b. metr/o
   c. -graphy
78. ureteroneocystostomy (ū-rē-ter-ō-nē-ō-sis-TOS-ō-mē) 
   a. ureter/o
   b. neo-
   c. cyst/o
   d. -stomy
Case Study 13-1: Renal Calculi

A.A., a 48-year-old woman, was admitted to the in-patient unit from the ER with severe right flank pain unresponsive to analgesics. Her pain did not decrease with administration of 100 mg of IV meperidine. She had a 3-month history of chronic UTI. Six months ago she had been prescribed calcium supplements for low bone density. Her gynecologist warned her that calcium could be a problem for people who are “stone-formers.” A.A. was unaware that she might be at risk. An IV urogram showed a right staghorn calculus. The diagnosis was further confirmed by a renal ultrasound. A renal flow scan showed normal perfusion and no obstruction. Kidney function was 37% on the right and 63% on the left. While the pain became intermittent, A.A. had no hematuria, dysuria, frequency, urgency, or nocturia. Urinalysis revealed no albumin, glucose, bacteria, or blood; there was evidence of cells, crystals, and casts.

A.A. was transferred to surgery for a cystoscopic ureteral laser lithotripsy, insertion of a right retrograde ureteral catheter, and right percutaneous nephrolithotomy. A ureteral calculus was fragmented with the pulsed-dye laser. Most of the staghorn was removed from the renal pelvis with no remaining stone in the renal calices. She was discharged 2 days later and ordered to strain her urine for the next week for evidence of stones.

Case Study 13-2: End-Stage Renal Disease

M.C., a 20-year-old part-time college student, has had chronic glomerulonephritis since age 7. He has been managed at home with CAPD for the last 16 months as he awaits a kidney transplant. His doctor advised him to go immediately to the ER when he complained of chest pain, shortness of breath, and oliguria. On admission, M.C. was placed on oxygen and given a panel of blood tests and an ECG to rule out an acute cardiac episode. His hemoglobin was 8.2 and hematocrit was 26%. He had bilateral lung rales. ABGs were: pH, 7.0; PaCO₂, 28; PaO₂, 50; HCO₃, 21. His BUN, serum creatinine, and BUN/creatinine ratio were abnormally high. His ECG and liver enzyme studies were normal. His admission diagnosis was ESRD, fluid overload, and metabolic acidosis. He was typed and crossed for blood; tested for HIV, hepatitis B antigen, and sexually transmitted disease; and sent to hemodialysis. A bed was reserved for him on the transplant unit.

Case Study 13-3: Set-Up for Cystoscopy

Renovations had been completed recently in the new surgical suite, and J.O., a surgical technologist, set up the two new adjoining “cysto” rooms. Each room had a new cystoscopy bed with padded knee crutches for lithotomy position, a drainage drawer for irrigation solution collection, and radiology capability. The instrument storage carts were stocked with rigid and flexible cystoscopes, sheaths with obturators, and resectoscopes with assorted fulgurating loops, connectors, guide wires, laser fibers, and fiberoptic light cords. Sterile storage closets held assorted urethral and ureteral catheters, irrigation tubing and syringes, collection bags, biopsy needles and forceps, basic soft tissue instruments, and dressing supplies.

An electrosurgery machine was placed in each room. Cysto no. 1 had the CMG machine and urinometer. Cysto no. 2 had a Nd:YAG (neodymium:yttrium-aluminum-garnet) and a liquid tunable pulsed-dye laser machine. Each room had a machine to collect and decontaminate the liquid waste, instead of the former floor drains.
The substerile room between Cysto no. 1 and no. 2 had a steam sterilizer, a peracetic acid processor/sterilizer, and glutaraldehyde soaking pans under a ventilation hood to high level-disinfect the instruments between cases. A warming closet contained blankets and sterile PSS, H2O, and glycine for bladder irrigation during the procedures. J.O. wished there was room left for an ESWL system.

**CASE STUDY QUESTIONS**

**Multiple choice:** Select the best answer and write the letter of your choice to the left of each number.

_____ 1. The term perfusion means:
   a. size
   b. shape
   c. passage of fluid
   d. surrounding tissue
   e. metabolism

_____ 2. M.C.’s chronic glomerulonephritis means that he has had:
   a. long-term kidney stones
   b. an acute bout of kidney infection
   c. short-term bladder inflammation
   d. a long-term kidney infection
   e. dysuria for 13 years

_____ 3. Renal dialysis can be performed by shunting venous blood through a dialysis machine and returning the blood to the patient’s arterial system. This procedure is called:
   a. hemodialysis
   b. arterio/venous transplant
   c. CAPD
   d. phlebotomy
   e. glomerular filtration rate

_____ 4. A surgical endoscope that can enter and visualize the bladder is a(n) __________, whereas a scope that cuts tissue is called a(n) __________.
   a. cystoscope, resectoscope
   b. resectoscope, fulgurating loop
   c. urinometer, obturator with sheath
   d. cystoscope, scissorscope
   e. urethroscope, ureteralscope

_____ 5. A transurethral approach for examination or surgery always begins with inserting a catheter or scope:
   a. through the ureter
   b. alongside of the urethra
   c. between the ureters
   d. through the urethra
   e. below the perineum
Write a term from the case studies with each of the following meanings:

6. intravenous injection of contrast dye and radiographic study of the urinary tract

7. production of a reduced amount of urine

8. getting up to go to the bathroom at night

9. crushing a stone in the ureter with a laser

10. kidney replacement

11. surgical incision for removal of a stone

Abbreviations. Define the following abbreviations:

12. UTI

13. CAPD

14. BUN

15. ESRD

16. HIV

17. CMG

18. PSS

19. ESWL
Chapter 13 Crossword
Urinary System

ACROSS
1. Tube that carries urine from the kidney to the bladder
5. Water; fluid: combining form
8. Cluster of capillaries in Bowman capsule
10. Few; scant: prefix
11. Microscopic functional unit of the kidney
13. Drug that reduces blood pressure, ____ inhibitor
14. Hormone that stimulates red cell production: abbreviation
15. Pertaining to the kidney
18. Measure of the weight of a substance as compared to water: abbreviation
19. Urinary bladder: combining form
21. Maximum amount of a substance that can be reabsorbed: abbreviation
22. Pituitary hormone that regulates water reabsorption: abbreviation
23. Excessive urination at night

DOWN
2. Kidney: combining form
3. Organism often involved in urinary tract infections, E. ____
4. Substance produced in response to renin that increases blood pressure
6. Painful or difficult urination
7. The fluid excreted by the kidneys
9. Large or abnormally large: prefix
12. Renal pelvis: combining form
16. Calculus (stone): combining form
17. Pus: root
20. Three: prefix
Answers to Chapter Exercises

EXERCISE 13-1

1. pararenal (par-a-RĒ-nal)
2. suprarenal (sū-pra-RĒ-nal)
3. interrenal (in-ter-RĒ-nal)
4. perirenal (per-i-RĒ-nal); circumrenal (sir-kum-RĒ-nal)
5. postrenal (post-RĒ-nal)
6. nephritis (nef-RĪ-tis)
7. nephropathy (nef-ROP-a-thē)
8. nephromalacia (nef-rō-ma-LĀ-shē-a)
9. nephrectomy (nef-REK-tō-mē)
10. nephrology (nef-ROG-ra-fe)
11. glomerulitis (glo-mer-ū-LĪ-tis)
12. calicectomy (kal-i-SEK-to)
13. pyelogram (pī-e-lō-gram)
14. pyelactasis (pī-e-LEK-ta-sis)
15. glomerulosclerosis (glo-mer-ū-skle-RŌ-sis)
16. renography (rē-NOG-ra-fē); nephrography (nef-ROG-ra-fē)
17. pyelonephritis (pī-e-lō-nef-RĪ-tis)

EXERCISE 13-2

1. urography (ū-ROG-ra-fē)
2. urolith (ū-lō-lith)
3. urology (ū-ROL-ō-jē)
4. uremia (ū-RĒ-mē-a)
5. proteinuria (prō-fē-NŪ-rē-a)
6. anuria (an-ū-rē-a)
7. polyuria (pol-ē-ū-rē-a)
8. dysuria (dis-ū-rē-a)
9. pyuria (pī-ū-rē-a)
10. cyturia (sī-TŪ-rē-a)
11. hematuria (hē-ma-TŪ-rē-a)
12. nocturia (nōk-TŪ-rē-a)
13. diuresis (dī-u-RE-sis)
14. anuresis (an-ū-RE-sis)
15. natriuresis (nā-trē-ū-RE-sis)
16. kaliuresis (kā-lē-ū-RE-sis)
17. urine
18. ureter
19. urethra
20. urinary bladder
21. urinary bladder
22. urethritis (ū-re-thRI-tis)
23. ureterolith (ū-RE-ter-ō-lith)
24. ureterostomy (ū-ū-re-thrō-OS-tō-mē)
25. urethropexy (ū-RE-thrō-pe-kē-sē)
26. cystitis (sis-TĪ-tis)
27. cystopexy (SIS-tō-pe-kē-sē)
28. cystoscope (SIS-tō-skōp)
29. cystocele (SIS-tō-sēl); also vesicocele (VES-i-kō-sēl)
30. prevesical (prē-VES-i-kāl)
31. urethrovresical (ū-rē-thrō-VES-i-kāl)
32. through the urethra
33. surgical creation of an opening in the bladder
34. surgical incision of the ureter
35. pain in the urinary bladder
36. formation of urine

LABELING EXERCISE 13-1 URINARY SYSTEM, WITH BLOOD VESSELS

1. diaphragm
2. adrenal gland
3. right kidney
4. ureter
5. urinary bladder
6. prostate gland
7. urethra
8. abdominal aorta
9. renal artery
10. common iliac artery
11. common iliac vein
12. renal vein
13. inferior vena cava

LABELING EXERCISE 13-2 LONGITUDINAL SECTION THROUGH THE KIDNEY

1. renal capsule
2. renal cortex
3. renal medulla
4. pyramids of medulla
5. calyx
6. renal pelvis
7. ureter

LABELING EXERCISE 13-3 INTERIOR OF THE URINARY BLADDER

1. ureter
2. smooth muscle
3. rugae
4. openings of ureters
5. trigone
6. internal sphincter
7. prostate
8. urethra
9. urogenital diaphragm
10. external sphincter

**Answers to Chapter Review 13-1**
1. e
2. b
3. a
4. c
5. d
6. e
7. b
8. d
9. a
10. c
11. c
12. e
13. b
14. a
15. d
16. b
17. a
18. e
19. c
20. d
21. d
22. a
23. c
24. e
25. b
26. b
27. e
28. d
29. c
30. a
31. nephron
32. glomerulus
33. medulla
34. urinalysis
35. ureter
36. urea
37. cast
38. like or resembling a kidney
39. acting on the kidney
40. near the glomerulus
41. inflammation of the urethra
42. pertaining to a calyx
43. narrowing of a urethra
44. painful or difficult urination
45. nephropathy
46. cystourethrogram
47. cystotomy
48. cystitis
49. pyelonephritis
50. nephrectomy
51. ureteropyeloplasty
52. ureterosigmoidostomy
53. pyelocalyctasis; pyelocalyctasis
54. dehydration
55. hypovolemia
56. antidiuretic
57. hyponatremia
58. anuresis
59. vesical
60. urologic
61. uremic
62. diuretic
63. caliceal
64. nephrotic
65. ureteral
66. urethral
67. glomeruli
68. calyces
69. pelves
70. intravenous pyelography
71. antidiuretic hormone
72. erythropoietin
73. blood urea nitrogen
74. urinary tract infection
75. glomerular filtration rate
76. urinalysis
77. test that measures and records bladder function
   a. urinary bladder
   b. measure
   c. act of recording data
78. surgical creation of a new passage between a ureter and the bladder
   a. ureter
   b. new
   c. bladder
   d. surgical creation of an opening

**Answers to Case Study Questions**
1. c
2. d
3. a
4. a
5. d
6. IV urogram
7. oliguria
8. nocturia
9. ureteral laser lithotripsy
10. kidney transplant
11. lithotomy
12. urinary tract infection
ANSWERS TO CROSSWORD PUZZLE

Urinary System

13. continuous ambulatory peritoneal dialysis
14. blood urea nitrogen
15. end-stage renal disease
16. human immunodeficiency virus
17. cystometrogram
18. physiologic saline solution
19. extracorporeal shock wave lithotripsy