LEARNING OBJECTIVES

- Present an overview of the organs and functions of the urinary system
- Describe the internal and external anatomy and physiology of the kidneys
- Discuss the importance of renal blood flow
- Describe the process of urine formation
- Trace the pathway of reabsorption or secretion of electrolytes and other chemicals
- List and discuss the importance of hormones for proper kidney function
- Describe the anatomy and physiology of the bladder and the process of urine removal from the body
- Discuss several common disorders of the urinary system
sphincter until they reach the age of 2. Boys develop control later than do girls, and it is not uncommon for boys to wet the bed until the age of 2.
ANSWERS TO THE CASE STUDY, P. 451

Jane’s diagnosis is overactive bladder. The other possibilities can be ruled out for the following reasons: no glucose rules out diabetes; no bacteria, blood, or leukocytes rules out urinary tract infection.

ANSWERS TO REVIEW QUESTIONS, P. 451

Multiple Choice
1. b, 2. d, 3. d, 4. b, 5. c, 6. a, 7. b, 8. b

Fill in the Blank
1. proximal tubule
2. nephron loop
3. atrial natriuretic peptide
4. pons
5. aldosterone
6. renal pelvis

Short Answer
1. There are several regulators of kidney function:
   - Autoregulation keeps filtration relatively constant even as blood pressure changes, protecting the filter from moment-to-moment changes in blood pressure.
   - The sympathetic nervous system controls filtration by release of epinephrine and norepinephrine from the renal medulla. Increased sympathetic response causes constriction of the afferent arteriole, decreasing glomerular filtration.
   - Antidiuretic hormone (ADH) is made by the hypothalamus and secreted from the posterior pituitary when BP decreases or ionic concentration increases.
     - ADH increases permeability of distal tubules and the collecting duct, causing more water to be reabsorbed and increasing blood pressure.
   - Aldosterone increases the reabsorption of sodium ions and secretion of potassium ions by the distal tubule and ascending limb of the nephron loop in response to decreased blood sodium. Urine volume also decreases.
   - Atrial natriuretic peptide is secreted by the atria of the heart when blood volume increases. ANP causes increased urination and decreased sodium reabsorption.
   - The renin-angiotensin-aldosterone system kicks in when blood flow to the kidney decreases. The kidney secretes renin. Renin converts angiotensinogen (from the liver) into angiotensin I. Angiotensin I is converted to angiotensin II by angiotensin-converting enzymes in the
lungs. Angiotensin II causes vasoconstriction, increased thirst, ADH secretion, and aldosterone secretion. All these mechanisms increase blood pressure.

2. The three processes necessary for urine formation are filtration, reabsorption, and secretion. Filtration is the movement of substances from plasma into the renal corpuscle. Most substances, except cells and large molecules, are filtered from blood. Reabsorption is the movement of substances from the renal tubules into the blood vessels surrounding the nephron. Substances that are reabsorbed are retained by the body. Tubular secretion is the movement of substances into the renal tubule from the bloodstream. Substances that are secreted leave the body in urine.

3. The bladder is lined with transitional epithelium with rugae. It has a muscular wall consisting of several layers of circular and longitudinal smooth muscle and is covered by connective tissue and parietal peritoneum.

4. Urination is controlled by neurons in the pons. As the bladder fills, stretch receptors signal neurons in the pons, which cause increased contraction of the smooth muscle in the bladder walls. This portion of urination is involuntary. Actual urination is controlled by sympathetic control of a pair of sphincters. You have some voluntary control of the sphincters.

5. A single renal artery enters each kidney at the hilum, branching into five segmental arteries that branch into lobar arteries, which branch into interlobar arteries, which pass through the renal columns. Arcuate arteries branch from the interlobar arteries and arch around the pyramids in the renal medulla. Cortical radiate (interlobular) arteries branch off arcuate arteries and give rise to afferent arterioles. Each afferent arteriole leads to a ball of capillaries called a glomerulus. Efferent arterioles leave from the glomerulus and travel to a specialized series of capillaries called the peritubular capillaries and vasa recta. From each set of peritubular capillaries, blood flows out the cortical radiate veins. From there, the blood flows out a series of veins that are the direct reverse of the arteries with the exception that there are no segmental veins. The blood finally leaves the kidney via the renal vein.

6. Most kidney disorders are characterized by too much or too little urine production or abnormalities in urine chemistry. Damage to the filtering apparatus, from diabetic nephropathy or glomeronephritis, causes blood and proteins to show up in the urine. Diabetes mellitus and insipidus both cause increase in urine volume. In DM it's because the body is making more urine trying to get rid of excess glucose. In DI it's because of the body's inability to control output because of ADH abnormalities. Disorders that cause damage to the filter will cause chemistry changes. Disorders that damage the tubule or the kidney in general will cause changes in volume. In end-stage renal disease, urine output may cease altogether as kidneys fail to function at all.