Part I. Clinical Applications

1. Mr. Bud Weiser is very drunk when he is brought to the emergency room after falling down the steps at the local football game. He is complaining about his dry mouth, being very thirsty and his excessive trips to the bathroom to urinate. Knowing the relationship between alcohol and ADH’s action, what is your explanation for why he is so thirsty and his excessive urination?

2. Cindy falls from her motorcycle and experiences a tremendous blow to her back. She comes to the emergency room complaining of extreme back pain. X-rays reveal that her right kidney has come loose. What is this condition called, why is this dangerous, and what is the treatment?

3. What are urinary tract infections and what are the symptoms? What is the UTI infection called if it causes inflammation within the urethra; urinary bladder; or kidneys? Why do women tend to get UTI’s more than men?
4. Mrs. Rodriques is breathing rapidly and is slurring her speech when her husband calls the clinic in a panic. Shortly after, she becomes comatose. Tests show that her blood glucose and ketone levels are high, and her husband said that she was urinating every few minutes before she became lethargic. What is Mrs. Rodrique’s problem? Would you expect her blood pH to be acidic or alkaline? What is the significance of her rapid breathing? Are her kidneys reabsorbing or secreting bicarbonate ions during this crisis?

5. You just find out that you have kidney stones. Your little sister (age 12) is worried that kidney stones are contagious and runs away from you screaming each time you are near her. Although funny at first, after a week of hearing her scream you feel that she is just becoming too annoying and decide to explain to her the medical explanation of kidney stones. What is your explanation? Be sure to include what kidney stones are, their composition, cause for getting stones and possible treatment.

6. Mr. I. P. Freely has had a series of laboratory tests including a CBC, lipid profile series, and urinalysis. The urinalysis revealed the presence of an abnormal amount of plasma proteins and white blood cells. (a) What is our diagnosis? (b) What effect does her condition have on her urine output?
<table>
<thead>
<tr>
<th>Acid-base</th>
<th>Peristalsis</th>
<th>Urethra</th>
<th>1 ½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidneys</td>
<td>Ureters</td>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Nitrogenous</td>
<td>Urinary bladder</td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>

**Part II**
Complete the following statements by inserting your answers in the answer blanks.

1. The kidney is referred to as an excretory organ because it excretes (1) wastes. It is also a major homeostatic organ because it maintains the electrolyte, (2) , and (3) balance of the blood. Urine is continuously formed by the (4) and is routed down the (5) by the mechanism of (6) to a storage organ called the (7). Eventually the urine is conducted to the body exterior by the (8). In males, this tube-like structure is about (9) inches long; in females, it is approximately (10) inches long.

2. About 600 Internal urethral Voluntarily
3. Contact Emotional /neural problems
4. Internal urethral Pressure (pregnancy)
5. Emotional /neural problems Prostate
6. Urinary bladder Stretch receptors
7. Urinary bladder Urinary retention

**Part III**
Complete the following statements by inserting your answers in the answer blanks.

1. Another term that means voiding or emptying of the bladder is (1). Voiding has both voluntary and involuntary aspects. As urine accumulates in the bladder, (2) are activated. This results in a reflex that causes the muscular wall of the bladder to (3), and urine is forced past the (4) sphincter. The more distal (5) sphincter is controlled (6); thus an individual can temporarily postpone emptying the bladder until it has accumulated (7) ml of urine. (8) is a condition in which voiding cannot be voluntarily controlled. It is normal in (9) because nervous control of the voluntary sphincter has not been achieved. Other conditions that might result in an inability to control the sphincter include (10) and (11). (12) is essentially the opposite of incontinence and often is a problem in elderly men because of (13) enlargement.
Part IV. Complete the following statements by inserting your answers in the answer blanks.

1. The glomerulus is a unique high-pressure capillary bed because the (1) arteriole feeding it is larger in diameter than the (2) arteriole draining the bed. Glomerular filtrate is very similar to (3), but it has fewer proteins. Mechanisms of tubular reabsorption include (4) and (5). As an aid for the reabsorption process, the cells of the proximal convoluted tubule have dense (6) on their luminal surface, which increase the surface area dramatically. Other than reabsorption, an important tubule function is (7), which is important for ridding the body of substances not already in the filtrate. Blood composition depends on (8), (9), and (10). In a day’s time, 180 liters of blood plasma are filtered into the kidney tubules, but only about (11) liters of urine are actually produced. (12) is responsible for the normal yellow color of urine. The three major nitrogenous wastes found in the blood, which must be disposed of, are (13), (14), and (15). The kidneys are the final “judges” of how much water is to be lost from the body. When water loss via vaporization from the (16) or (17) from the skin is excessive, urine output (18). If the kidneys become nonfunctional, (19) is used to cleanse the blood of impurities.

20- Protein-rich diet
21- Bacterial infection
22- Starvation
23- Diabetes mellitus
24- Vegetarian diet
Part II. Figure 15-3 is a diagram of the nephron and associated blood supply. First, match each of the numbered structures on the figure to one of the terms below the figure. Place the terms in the numbered spaces provided below. Then color the structure on the figure that contains podocytes green; the filtering apparatus red; the capillary bed that directly receives the reabsorbed substances from the tubule cells blue; the structure into which the nephron empties its urine product yellow; and the tubule area that is the primary site of tubular reabsorption orange.

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ___________
11. ____________
12. ____________
13. ____________
14. ____________
15. ____________

Afferent arteriole
Arcuate artery
Arcuate vein
Glomerular capsule
Collecting duct
Distal convoluted tubule
Efferent arteriole
Glomerulus
Interlobar artery
Interlobar vein
Cortical radiate artery
Cortical radiate vein
Loop of Henle
Proximal convoluted tubule
Peritubular capillaries
Glucose and albumin are both normally absent from urine, but the reason for their exclusion differs. Respond to the following questions in the spaces provided.

16. Explain the reason for the absence of glucose in urine.

17. Explain the reason for the absence of albumin in urine.

Part II Using the key choices, identify the structures that best fit the following descriptions. Insert the correct term(s) or corresponding letter(s) in the answer blanks.

Key Choices
- Bladder
- Urethra
- Ureter

1. Drains the bladder
2. Storage area for urine
3. Contains the trigone
4. In males has prostatic, membranous, and spongy parts
5. Conducts urine by peristalsis
6. Substantially longer in males than in females
7. A common site of "trapped" renal calculi
8. Contains transitional epithelium
9. Also transports sperm in males

Define GFR in this exercise.

10. To what do the letters GFR refer? g_____________ f_____________
    r_____________

11. Write a normal value for GFR: _____ mL/min. Multiplying this by 1440 min/day (60 min/hour × 24 hours/day), the amount of fluid moving from glomerular blood to filtrate is _____ mL/day (or _____ L/day).

12. Describe these two causes of decreased GFR. GFR is likely to decrease if blood pressure in kidneys ______-creases.
    This can result from sympathetic nerve-induced vaso-_______ of renal vessels during stress.
    Either an enlarged prostate gland or kidney _______ lodged in the ureter will cause a backup of urine into renal tubules of the kidneys, opposing glomerular blood pressure, and this will decrease GFR also.
13. (Most? Only a few?) types of substances are forced out of blood in the process of glomerular filtration. In fact, during filtration all solutes are freely filtered from blood, but two large components of blood (____________________ and____________________) do not pass across the glomerular membrane.

14. Blood pressure in glomerular capillaries is (higher? lower?) than that in other capillaries of the body. This extra pressure is accounted for by the fact that the diameter of the efferent arteriole is (larger? smaller?) than that of the afferent arteriole. Picture three garden hoses connected to each other, representing the afferent arteriole, glomerular capillaries, and efferent arteriole. The third one (efferent arteriole) is extremely narrow; it creates such resistance that pressure builds up in the first two. Fluids are forced out through the highly permeable middle (glomerular) hose.

Now identify functions of the four "A" hormones that regulate urinary output. Choose from answers in the box.

<table>
<thead>
<tr>
<th>ADH. Antidiuretic hormone</th>
<th>Ang. II. Angiotensin II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ald. Aldosterone</td>
<td>ANP. Atrial natriuretic peptide</td>
</tr>
</tbody>
</table>

15. A vasoconstrictor that also stimulates release of aldosterone.
16. Produced by the adrenal cortex, it causes collecting ducts to reabsorb more Na⁺ and water and increases secretion of K⁺.
17. A hormone produced by heart cells, this chemical opposes the actions of renin, aldosterone, and ADH as it increases GFR.

19. Diuretics have the (same effect as? opposite effect to?) ADH. Diuretics ________-crease urinary output and ________-crease blood volume. Therefore they tend to ________-crease blood pressure. List four commonly ingested fluids that have diuretic effects.

20. Denise has been diagnosed with diabetes mellitus. Her blood glucose level is often higher than ideal. Explain how this condition can lead to:

a. Glycosuria

b. Polyuria

21. Do this exercise on urinary tract infections (UTIs).

a. UTIs typically occur more often in (women? men?). State a rationale for this fact.

b. Which bacteria most often cause UTIs? ________________ Which microbe is most often the cause of "yeast infections" of the vagina or urethra? ________________

c. List common signs and symptoms of UTIs.

d. List three health practices that can reduce risk of UTIs.
Part VII

1. Urine leaving the kidneys travels along the following sequential pathway to the exterior:
   a. ureters, urinary bladder, urethra
   b. urethra, urinary bladder, ureters
   c. urinary bladder, ureters, urethra
   d. urinary bladder, urethra, ureters

2. Which organ or structure does not belong to the urinary system?
   a. urethra
   b. gallbladder
   c. kidneys
   d. ureters

3. The openings of the urethra and the two ureters mark an area on the internal surface of the urinary bladder called the:
   a. internal urethral sphincter
   b. external urethral sphincter
   c. trigone
   d. renal sinus

4. The basic functional unit in the kidney is the:
   a. glomerulus
   b. loop of Henle
   c. Bowman's capsule
   d. nephron

5. Dilation of the afferent arteriole and glomerular capillaries and constriction of the efferent arteriole causes:
   a. elevation of glomerular blood pressure to normal levels
   b. a decrease in glomerular blood pressure
   c. a decrease in the glomerular filtration rate
   d. an increase in the secretion of renin and erythropoietin

6. In a nephron, the long tubular passageway through which the filtrate passes includes:
   a. collecting tubule, collecting duct, papillary duct
   b. renal corpuscle, renal tubule, renal pelvis
   c. proximal and distal convoluted tubules and loop of Henle
   d. loop of Henle, collecting and papillary duct

7. The portion of the renal segment that is under ADH and aldosterone stimulation is the:
   a. proximal convoluted tubule
   b. Loop of Henle
   c. vasa recta
   d. distal convoluted tubule

8. A radiologist is examining an X ray of the lumbar region of a patient. Which of the following is/are indicative of normal positioning of the right kidney?
   A. Slightly higher than the left kidney
   B. More medial than the left kidney
   C. Closer to the inferior vena cava than the left kidney
   D. Anterior to the 12th rib

9. What is the glomerulus?
   A. The same as the renal corpuscle
   B. The same as the renal tubule
   C. The same as the nephron
   D. Capillaries

10. Urine passes through the ureters by which mechanism?
    A. Ciliary action
    B. Peristalsis
    C. Gravity alone
    D. Suction

11. Jim was standing at a urinal in a crowded public restroom and a long line was forming behind him. He became anxious (sym pathetic response) and found he could not urinate no matter how hard he tried. Use logic to deduce Jim's problem.
    A. His internal urethral sphincter was constricted and would not relax.
    B. His external urethral sphincter was constricted and would not relax.
    C. His detrusor muscle was contracting too hard.
    D. He almost certainly had a burst bladder.

12. The three primary waste products found in a representative urine sample are:
    a. ions, metabolites, nitrogenous wastes
    b. urea, creatinine, uric acid
    c. glucose, lipids, proteins
    d. sodium, potassium, chloride
Part VIII

Describe typical aging changes of the urinary system by filling in the blanks with terms in the box. Use each term once.

| Decrease | Nephritis |
| Dysuria | Nocturia |
| Hematuria | Pyuria |
| Increase | Renal calculi |

1. With aging, kidney mass, renal blood flow, GFR, and urinary output all tend to ______________________.

   Frequency of kidney inflammations known as ____________________ and kidney stones
   ( ____________________ ) are greater in older adults. These conditions are two possible causes of blood
   in the urine ( ____________________ ).

2. Frequency of UTIs is likely to ____________________ related to prostate enlargement in men or decreased
   amounts of urine “flushing” the urinary tract in either gender. UTIs are often associated with painful urination
   ( ____________________ ) and urinary frequency. White blood cells in urine ( ___________ ) can also
   indicate UTIs.

3. Weakness of urethral sphincters (and prostate enlargement in men) may contribute to the need to urinate
   frequently throughout the night ( ____________________ ).

4. Complete this Checkpoint by identifying body systems on which the urinary system exerts its impact.
   Kidneys play a critical role in regulating blood levels of calcium and phosphates that affect the
   ____________________ system(s).

5. The male urethra functions in two systems: one is the urinary system, the other is the
   ________________

   Kidneys synthesize renin and erythropoietin, and also regulate blood volume levels that impact the
   ____________________ system.

As discussed in Chapter 22, blood pH is regulated largely by the urinary and the ________________ systems.

6. Fill in blanks in this exercise with terms in the box. Use each term once.

   | Anuria        | Intravenous pyelogram |
   | Dialysis     | Oliguria               |
   | Diuresis     | Polycystic renal disease |
   | End-stage renal failure | Polyuria |
   | Enuresis     | Uremia                 |

7. When kidneys fail, wastes such as urea and creatinine remain in blood, and may reach a toxic level, the condition
   known as ____________________. This is a sign of ____________________. A procedure known as
   __________ cleanses blood of toxic wastes, and can prolong life of persons in renal failure.
8. One cause of end-stage renal failure is __________, a quite common hereditary disease in which kidney tissue is replaced by useless fluid-filled cysts.

9. Failing kidneys may lead to a decreased urine volume (__________________) or eventually virtually no urine (__________________).

10. A large urinary output may be described by two terms: ____________________ or ____________________.

11. Bed-wetting, as occurs in about 15% of 5-year-old children, is known as ____________________.
    An x-ray of kidneys after venous injection of dye, for example to test for kidney stones, is called a(n) ____________________.
Part IX

1. The mechanism important in the reabsorption of glucose and amino acids when their concentrations in the filtrate are relatively high is:
   a. active transport
   b. secondary active transport
   c. co-transport
   d. countertransport

2. The glomerular filtration rate is regulated by:
   a. autoregulation
   b. hormonal regulation
   c. autonomic regulation
   d. a, b, and c are correct

3. The primary site of nutrient reabsorption in the nephron is the:
   a. proximal convoluted tubule
   b. distal convoluted tubule
   c. loop of Henle
   d. renal corpuscle

4. In countercurrent multiplication, the countercurrent refers to the fact that an exchange occurs between:
   a. sodium ions and chloride ions
   b. fluids moving in opposite directions
   c. potassium and chloride ions
   d. solute concentrations in the Loop of Henle

5. The result of the countercurrent multiplication mechanism is:
   a. decreased solute concentration in descending limb of Loop of Henle
   b. decreased transport of sodium and chloride in ascending limb of Loop of Henle
   c. increased solute concentration in descending limb of Loop of Henle
   d. osmotic flow of water from peritubular fluid into descending limb of Loop of Henle

6. When antidiuretic hormone levels rise the distal convoluted tubule becomes:
   a. less permeable to water; reabsorption of water decreases
   b. more permeable to water; water reabsorption increases
   c. less permeable to water; reabsorption of water increases
   d. more permeable to water; water reabsorption decreases

7. The results of the effect of aldosterone along the DCT, the collecting tubule, and the collecting duct are:
   a. increased conservation of sodium ions and water
   b. increased sodium ion excretion
   c. decreased sodium ion reabsorption in the DCT
   d. increased sodium ion and water excretion
8. The hormones that affect the glomerular filtration rate (GFR) by regulating blood pressure and volume are:
   a. aldosterone, epinephrine, oxytocin
   b. insulin, glucagon, glucocorticoids
   c. renin, erythropoietin, ADH
   d. a, b, and c are correct

9. Angiotensin II is a potent hormone that:
   a. causes constriction of the efferent arteriole at the nephron
   b. triggers the release of ADH in the CNS
   c. stimulates secretion of aldosterone by the adrenal cortex and epinephrine by the adrenal medulla
   d. a, b, and c are correct

10. Sympathetic innervation of the afferent arterioles causes a(n):
    a. decrease in GFR and slowing of filtrate production
    b. increase in GFR and an increase in filtrate production
    c. decrease in GFR and an increase in filtrate production
    d. increase in GFR and a slowing of filtrate production

11. During periods of strenuous exercise, sympathetic activation causes the blood flow to:
    a. decrease to skin and skeletal muscles; increase to kidneys
    b. cause an increase in GFR
    c. increase to skin and skeletal muscles; decrease to kidneys
    d. be shunted toward the kidneys

12. When plasma glucose concentrations are higher than the renal threshold, glucose concentrations in the filtrate exceed the tubular maximum ($T_m$) and:
    a. glucose is transported across the membrane by counter-transport
    b. the glucose is filtered out at the glomerulus
    c. glucose appears in the urine
    d. the individual has eaten excessive amounts of sweets

13. The filtration process within the renal corpuscle involves passage across three physical barriers, which include the:
    a. podocytes, pedicels, slit pores
    b. capillary endothelium, basement membrane, glomerular epithelium
    c. capsular space, tubular pole, macula densa
    d. collecting tubules, collecting ducts, papillary ducts

14. The thin segments in the loop of Henle are:
    a. relatively impermeable to water; freely permeable to ions and other solutes
    b. freely permeable to water, ions, and other solutes
    c. relatively impermeable to water, ions, and other solutes
    d. freely permeable to water; relatively impermeable to ions and other solutes
Where necessary, complete statements by inserting the missing word(s) in the answer blanks.

For your journey through the urinary system, you must be made small enough to filter through the filtration membrane from the bloodstream into a renal (1). You will be injected into the subclavian vein and must pass through the heart before entering the arterial circulation. As you travel through the systemic circulation, you have at least 2 minutes to relax before reaching the (2) artery, feeding a kidney. You see the kidney looming brownish red through the artery wall. Once you have entered the kidney, the blood vessel conduits become increasingly smaller until you finally reach the (3) arteriole, feeding into the filtering device, or (4). Once in the filter, you maneuver yourself so that you are directly in front of a pore. Within a fraction of a second, you are swept across the filtration membrane into the (5) part of the nephron. Drifting along, you lower the specimen cup to gather your first filtrate sample for testing. You study the readout from the sample and note that it is very similar in composition to (6) with one exception: There are essentially no (7). Your next sample doesn’t have to be collected until you reach the “hairpin,” or, using the proper terminology, the (8) part of the tubule. As you continue your journey, you notice that the tubule cells have dense fingerlike projections extending from their surfaces into the lumen of the tubule. These are (9), which increase the surface area of tubules because this portion of the tubule is very active in the process of (10). Soon you collect your second sample, and then later, in the distal convoluted tubule, your third sample. When you read the computer’s summary of the third sample, you make the following notes in your register.

- Virtually no nutrients such as (11) and (12) are left in the filtrate.

- The pH is acidic, 6.0. This is quite a change from the pH of (13) recorded for the newly formed filtrate.

- There is a much higher concentration of (14) wastes here.

- There are many fewer (15) ions but more of the (16) ions noted.
19. • Color of the filtrate is yellow, indicating a high relative concentration of the pigment (17).

20. Gradually you become aware that you are moving along much more quickly. You see that the water level has dropped dramatically and that the stream is turbulent and rushing. As you notice this, you realize that the hormone (18) must have been released recently to cause this water drop. You take an abrupt right turn and then drop straight downward. You realize that you must be in a (19). Within a few seconds, you are in what appears to be a large tranquil sea with a tide flowing toward a darkened area at the far shore. You drift toward the darkened area, confident that you are in the kidney (20). As you reach and enter the dark tubelike structure seen from the opposite shore, your progress becomes rhythmic—something like being squeezed through a sausage skin. Then you realize that your progress is being regulated by the process of (21). Suddenly, you free-fall and land in the previously stored (22) in the bladder, where the air is very close. Soon the walls of the bladder begin to gyrate, and you realize you are witnessing a (23) reflex. In a moment, you are propelled out of the bladder and through the (24) to exit from your host.

Part XI
Assuming normal conditions, note whether each of the following substances would be (G) in greater concentration in the urine than in the glomerular filtrate, (L) in lesser concentration in the urine than in the glomerular filtrate, or (A) absent in both urine and glomerular filtrate. Place the correct letter in the answer blanks.


Part XII
Several specific terms are used to indicate the presence of abnormal urine constituents. Identify each of the following abnormalities by inserting the term that names the condition in the spaces provided. Then for each condition, provide one possible cause of the condition in the remaining spaces.

1. Presence of red blood cells: Cause:
2. Presence of ketones: Cause:
3. Presence of albumin: Cause:
4. Presence of pus: Cause:
5. Presence of bile: Cause:
6. Presence of "sand": Cause:
7. Presence of glucose: Cause:
Body Trek:

Using the terms below, fill in the blanks to complete the trek through the urinary system.

| aldosterone | protein-free | ions |
| ascending limb | active transport | ADH |
| glomerulus | urine | urinary bladder |
| collecting | proximal | descending limb |
| urethra | filtrate | ureters |
| distal |

Robo’s trek through the urinary system begins as the tiny robot is inserted into the urethra and with the aid of two mini-rockets is propelled through the urinary tract into the region of the renal corpuscle in the cortex of the kidney. The use of the mini-rockets eliminates the threat of the counter-current flow of the filtrate and the urine and the inability of the robot to penetrate the physical barriers imposed in the capsular space.

Rocket shutdown occurs just as Robo comes into contact with a physical barrier, the filtration membrane. The robot’s energizers are completely turned off because the current produced by the fluid coming through the membrane is sufficient to “carry” the robot as it treks through the tubular system.

As the fluid crosses the membrane it enters into the first tubular conduit, the (1) _______ convoluted tubule, identifiable because of its close proximity to the vascular pole of the (2) _______. Robo’s chemosensors detect the presence of a (3) _______ filtrate in this area. Using the current in the tubule to move on, the robot’s speed increases because of a sharp turn and descent into the (4) _______ of Henle, where water reabsorption and concentration of the (5) _______ are taking place. The trek turns upward after a “hairpin” turn into the (6) _______ of Henle where, in the thickened area, (7) _______ mechanisms are causing the reabsorption of (8) _______.

The somewhat “refined” fluid is delivered to the last segment of the nephron, the (9) _______ convoluted tubule, which is specially adapted for reabsorption of sodium ions due to the influence of the hormone (10) _______, and in its most distal position, the effect of (11) _______, causing an osmotic flow of water that assists in concentrating the filtrate.

Final adjustments to the sodium ion concentration and the volume of the fluid are made in the (12) _______ tubules, which deliver the waste products in the form of (13) _______ to the renal pelvis. It will then be conducted into the (14) _______ on its way to the (15) _______ for storage until it leaves the body through the (16) _______ — Robo’s way of escaping the possibility of toxicity due to the “polluted” environment of the urinary tract.