Exercise 34

The Urinary Organs

* class set

Use "Laboratory Report" Sheet

Objectives

After completing this exercise, you should be able to:

1. Identify the components of the urinary system on charts or models and describe their functions.
2. Identify the parts of the kidney on charts, models, or specimens and describe their functions.
3. Identify a glomerulus and Bowman's capsule when viewed microscopically.
4. Define all terms in bold print.

Materials

Models of the urinary system and a kidney
Prepared slides of kidney tissue
Sheep kidneys, fresh or preserved
Sheep kidneys, triple injected
Dissecting kits and trays
Long, sharp knife
Prepared slides of kidney cortex and medulla

Organs of the Urinary System

The components of the urinary system are shown in Figure 34.1: two kidneys, two ureters, the urinary bladder, and the urethra. The **kidneys** are bean-shaped, reddish-brown organs located on either side of the vertebral column and posterior to the parietal peritoneum. Each kidney receives blood from a **renal artery,** which branches from the **abdominal aorta.** Blood leaves each kidney through a **renal vein,** which empties into the **inferior vena cava.**

Urine, formed by the kidneys, is carried from each kidney to the **urinary bladder** through a slender tube, a **ureter.** Peristaltic contractions of the ureter wall propel the urine to the bladder. Each ureter originates as a funnel-like **renal pelvis** in the kidney and descends parallel to the vertebral column and posterior to the peritoneum. The lower end enters the posterior surface of the urinary bladder.

Urine is temporarily stored in the distensible urinary bladder and then voided from the bladder via a short tube, the **urethra.** The male urethra is about 20 cm in length; the female urethra is approximately 4 cm in length.

Figure 34.1 The urinary system.

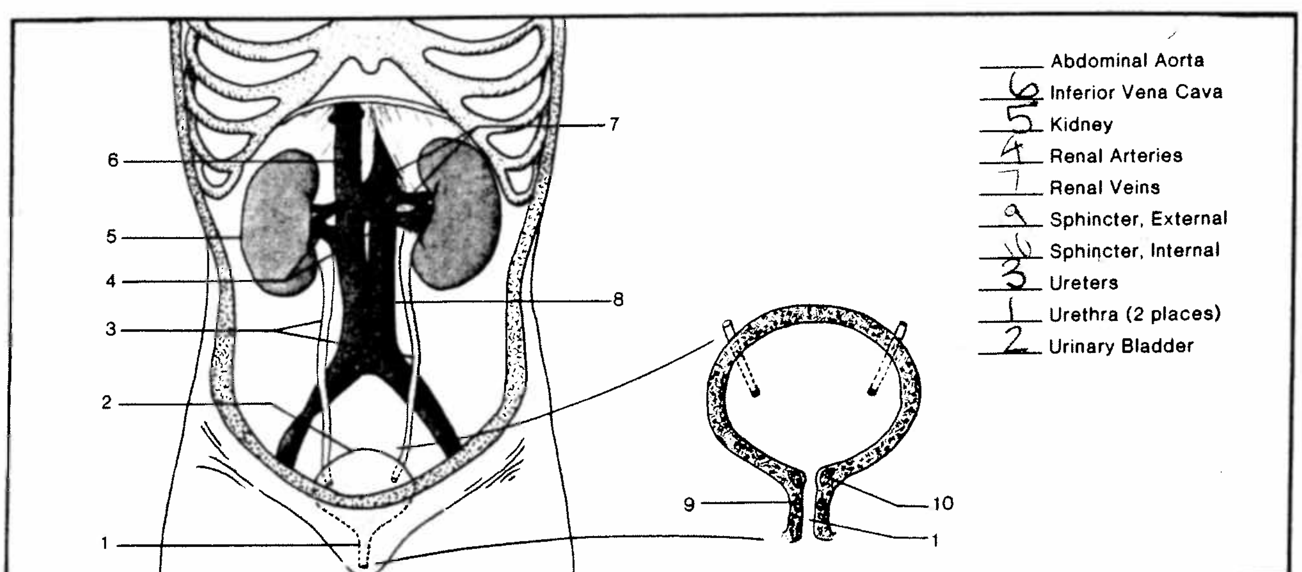
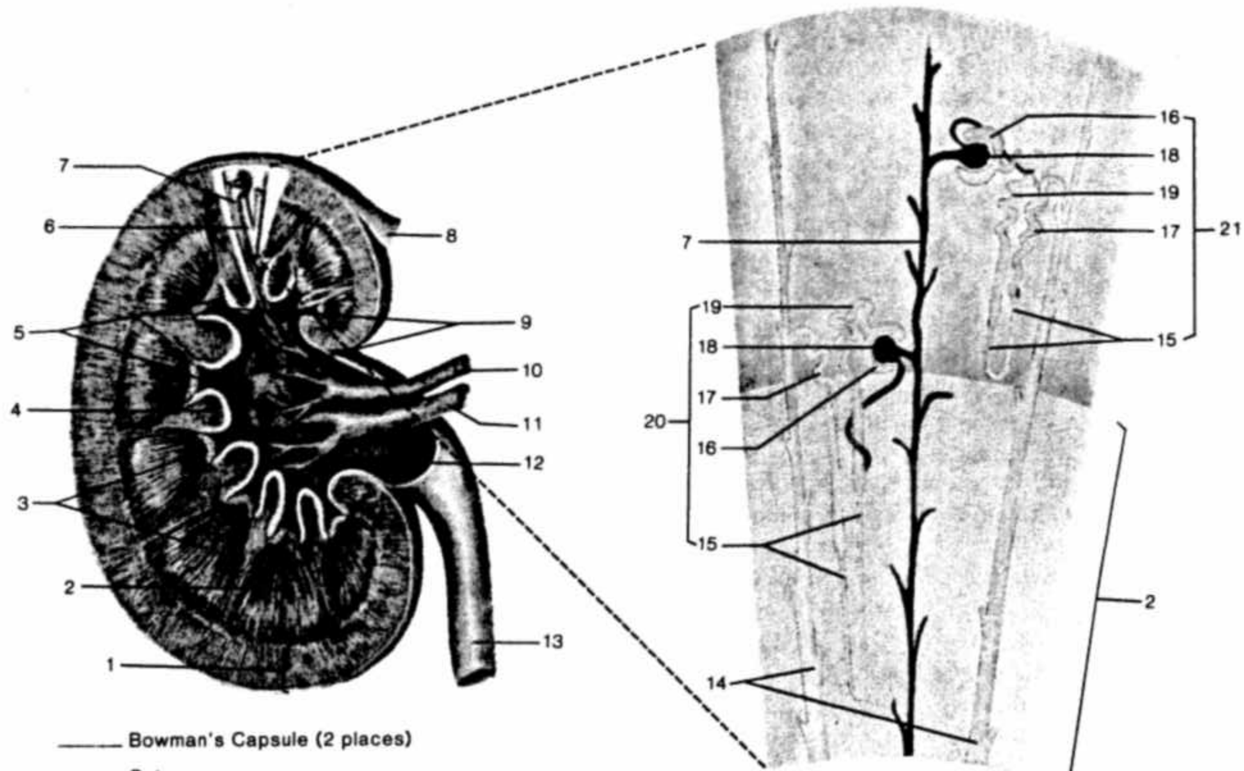


Figure 34.2 Anatomy of the kidney.



_____ Bowman's Capsule (2 places)
_____ Calyces
_____ Collecting Ducts
_____ Cortex
_____ Cortical Nephron
_____ Distal Convoluted Tubule (2 places)
_____ Glomerulus (2 places)
_____ Henle's Loop (2 places)
_____ Interlobular Artery (2 places)
_____ Interlobular Vein
_____ Juxtamedullary Nephron
_____ Medulla (2 places)
_____ Proximal Convoluted Tubule (2 places)
_____ Renal Artery
_____ Renal Capsule
_____ Renal Column
_____ Renal Papillae
_____ Renal Pelvis
_____ Renal Pyramids
_____ Renal Vein
_____ Ureter

Cystitis, inflammation of the urinary bladder, is more common in females than males since the shorter length of the female urethra provides an easier entrance for pathogens.

The passage of urine from the bladder is called **micturition** and is controlled by two sphincter muscles. The **internal sphincter** is located at the junction of the bladder and urethra. It is formed of smooth muscle and is under parasympathetic control. The **external sphincter** is located in the urethra about 2 cm from the bladder. It consists of skeletal muscle and is under voluntary control.

When about 300 ml of urine has accumulated in the urinary bladder, the stretching of the bladder walls initiates an urge to urinate and a subconscious reflex, which causes the walls to contract. This contraction forces urine past the internal sphincter to the external sphincter, creating a sensation of urgency. When the external sphincter is consciously relaxed, micturition occurs.

Incontinence is the lack of voluntary control of micturition. It is normal in infants until the neurons to the external sphincter develop, and voluntary control is learned through training.

Assignment

1. Label Figure 34.1.
2. Locate the parts of the urinary system on the model and note their relationships to the adjacent structures.

Kidney Anatomy

The basic structure of the kidney is shown in Figure 34.2. The thin outer covering of the kidney is the **renal capsule,** a fibrous membrane. Exterior to this membrane, there is usually a thick protective layer of fatty tissue (not shown).

There are two major parts of the kidney. An outer, reddish-brown **cortex** lies just under the renal capsule. The lighter-colored **medulla** forms the interior of the kidney. The medulla is divided into the cone-shaped **renal pyramids,** which are separated by extensions of the cortex called **renal columns.** The tip of a renal pyramid is the **renal papilla,** which projects into a calyx. The **calyces** are short tubes that receive urine from the renal papillae and empty into the funnel-shaped **renal pelvis.** The renal pelvis is continuous with the enlarged upper end of the ureter.

The Nephron

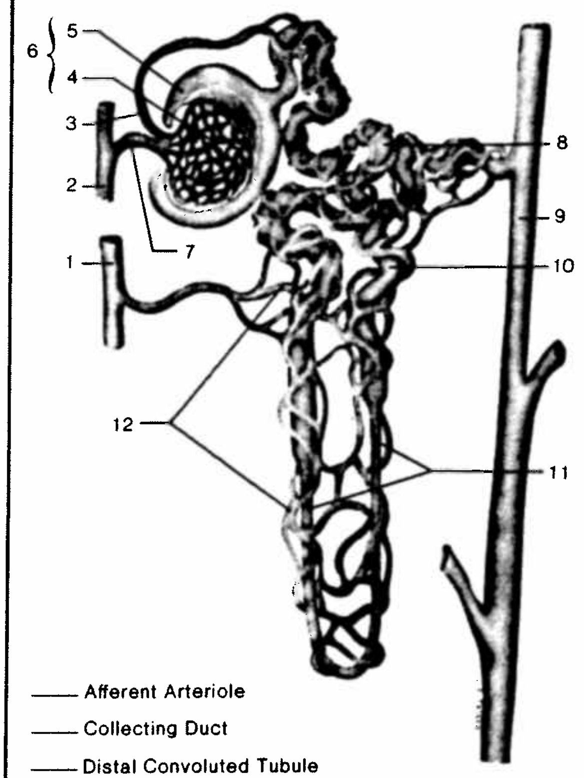
The functional unit of the kidney is the **nephron.** About one million nephrons are in each kidney. Each nephron consists of two major parts: a renal corpuscle and a renal tubule. A **renal corpuscle** consists of an inner tuft of capillaries, the **glomerulus,** and an outer, double-walled **glomerular** or **Bowman's capsule** that envelopes the glomerulus. A **renal** tubule consists of three sequential segments: (1) the **proximal convoluted tubule** leads from Bowman's capsule, (2) **Henle's loop** is the downward U-shaped portion, and (3) the **distal convoluted tubule** is the terminal segment that empties into a collecting duct. Several tubules empty into a single **collecting duct.**

Most nephrons (80%) are **cortical nephrons** that are entirely located in the cortex; their short Henle's loops rarely enter the medulla. **Juxtamedullary nephrons** have a long Henle's loop that penetrates deeply into the medulla. See Figure 34.2. Figure 34.3 shows a nephron in more detail with associated blood vessels.

Urine Formation Nephrons form urine by three processes: (1) filtration, (2) reabsorption, and (3) secretion. In this way, water and essential substances in the blood are conserved while the concentrations of surplus substances, including **nitrogenous wastes** (urea, uric acid, and creatinine), are reduced. It is the process of urine formation that maintains the normal concentration of substances in blood plasma.

Blood enters the kidney through the **renal artery** and reaches each nephron via an **interlobular artery** (label 7, Figure 34.2; label 2, Figure 34.3). A short **afferent arteriole** carries blood from the interlobular artery to the glomerulus. An **efferent arteriole** carries blood from the glomerulus to the **peritubular capillaries** that enmesh the nephron tubule. Blood from the capillaries drains into the **interlobular vein** (label 8, Figure 34.2; label 1, Figure 34.3) that empties into the **renal vein.**

Figure 34.3 The nephron.



____ Afferent Arteriole
____ Collecting Duct
____ Distal Convoluted Tubule
____ Efferent Arteriole
____ Glomerular Capsule
____ Glomerulus
____ Henle's Loop
____ Interlobular Artery
____ Interlobular Vein
____ Peritubular Capillaries
____ Proximal Convoluted Tubule
____ Renal Corpuscle

The efferent arteriole has a smaller diameter than the afferent arteriole. This elevates the blood pressure within the glomerulus and forces the **glomerular filtrate,** a dilute fluid derived from blood plasma, into the glomerular capsule. About 600 ml of blood plasma flows through the glomeruli each minute; 860 liters in 24 hours. The kidneys form about 125 ml of filtrate per minute; 180 liters per day. The filtrate consists of all substances present in the blood except the formed elements. However, very few plasma proteins enter the filtrate because their molecules are too large.

As the filtrate passes through the renal tubule, various substances are reabsorbed into the peritubular capillaries. For example, almost all of the proteins that enter the filtrate are reabsorbed by tubule cells. A few substances are secreted from the capillaries into the filtrate.

Table 34.1 Quantity of selected substances in: (1) blood plasma flowing through the kidneys, (2) filtrate passing through Bowman's capsule, and (3) urine formed in a 24-hour period.

Substance	Plasma	Filtrate	Urine
Total Volume	860 l	180 l	1 l
Proteins	7,500 g	10 g	0
Chloride ions	3,180 g	667 g	7 g
Potassium ions	170 g	36 g	3 g
Sodium ions	2,924 g	612 g	5 g
Glucose	860 g	180 g	0
Creatinine	8.6 g	1.5 g	1.5 g
Urea	215 g	45 g	25 g
Uric acid	43 g	9 g	0.8 g

This selective reabsorption and secretion of substances by the renal tubule play a major role in maintaining the constancy of the body fluids.

The remaining filtrate passes into a collecting duct, where it may be further concentrated or diluted by the reabsorption of water or mineral ions. When it reaches the renal pelvis, it is called urine. Table 34.1 compares the quantity of selected substances in blood plasma, tubule filtrate, and urine.

Assignment

1. Label Figures 34.2 and 34.3.
2. Complete Sections A, B, and C on the laboratory report.
3. Examine a sectioned, triple-injected kidney under a demonstration dissecting microscope. Note the many renal corpuscles. Can you distinguish the glomerulus, Bowman's capsule, and tubules?
4. Examine a prepared slide of kidney cortex and medulla. Compare your observations with Figure HA-21 and locate the labeled structures. Note that the walls of Bowman's capsule and the renal tubule are only one cell thick. Make diagrams of your observations on the laboratory report.

Sheep Kidney Dissection

1. Obtain a sheep kidney for study. If it is still encased in fat, remove the fat carefully with your hands. Look for the adrenal gland embedded in the fat near one end of the kidney. Cut the gland in half and note that it has a distinct outer cortex and an inner medulla.
2. Insert a dissecting needle into the kidney to distinguish the tougher renal capsule from the softer underlying tissue.
3. With a long, sharp knife, cut the kidney longitudinally to make a frontal section similar to Figure 34.2. Wash the cut surfaces.
4. Locate all of the macroscopic structures shown in Figure 34.2.
5. Complete the laboratory report.

Laboratory Report **34**

Student ______________________

Lab Section ______________

The Urinary Organs

A. Figures

List the labels for Figures 34.1, 34.2, and 34.3.

Figure 34.1

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
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9. ______________
10. ______________

Figure 34.2

1. ______________
2. ______________
3. ______________
4. ______________
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17. ______________
18. ______________
19. ______________
20. ______________
21. ______________

Figure 34.3

1. ______________
2. ______________
3. ______________
4. ______________
5. ______________
6. ______________
7. ______________
8. ______________
9. ______________
10. ______________
11. ______________

B. Anatomy

Select the structures described by the statements below.

Bowman's capsule	medulla	renal pelvis
calyces	nephron	renal pyramids
collecting duct	renal capsule	ureters
cortex	renal column	urethra
glomerulus	renal papilla	

1. Tubes that drain the kidneys.
2. Tube that drains the urinary bladder.
3. Portion of kidney that contains renal corpuscles.
4. Cone-shaped portions of the medulla.
5. Part of kidney containing collecting ducts.
6. Functional unit of the kidney.
7. Capillary tuft within renal corpuscle.
8. Tip of renal pyramid.
9. Tube receiving urine from several nephrons.
10. Thin, fibrous covering of the kidney.
11. Cortical tissue between renal pyramids.
12. Short tubes receiving urine from renal pyramids.
13. Part of kidney composed of renal pyramids and renal columns.
14. Funnel-like structure receiving urine from calyces.
15. Cup-like structure enveloping a glomerulus.

Anatomy

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

C. Table 34.1

Calculate the concentrations (grams/liter) of the following substances in Table 34.1 and record them below.

Substance	Plasma	Filtrate	Urine
Proteins	__________	__________	__________
Chloride ions	__________	__________	__________
Potassium ions	__________	__________	__________
Sodium ions	__________	__________	__________
Glucose	__________	__________	__________
Creatinine	__________	__________	__________
Urea	__________	__________	__________
Uric acid	__________	__________	__________

1. Why do so few proteins enter the filtrate? ______________________________

2. What substances have different concentrations in the plasma and in the filtrate? ____________________

3. What substances are completely reabsorbed? ______________________________

4. What substances are more concentrated in urine than in the filtrate? ____________________

5. Does urine formation remove all nitrogenous wastes or only reduce their concentrations in the plasma? __________

6. What percentage of the filtrate is reabsorbed? ______________________________

   The reabsorption of what substance accounts for most of the volume reduction and the concentration of urine solutes? ______________________________

7. List the three processes of urine formation.

   ____________________ ____________________ ____________________

D. Microscopic Study

Diagram a glomerulus and Bowman's capsule as observed on the prepared slide of kidney tissue.