Urinary Structures

The **urinary system** is composed of the **kidneys, ureters, urinary bladder, urethra,** and associated structures. The functions of the urinary system include maintaining extracellular fluid balance, excreting wastes, and maintaining blood pH.

In this exercise, you are challenged to discover the basic anatomy of the urinary system on both the gross and microscopic levels. In Lab Exercise 48, you will have the opportunity to dissect urinary structures in a whole specimen. In Lab Exercise 49, you will analyze the components of the **urine** produced by this system.

Before you begin

- ❑ Read the appropriate chapter in your textbook.
- ❑ Set your learning goals. When you finish this exercise, you should be able to:
  - ❑ identify the major organs of the urinary system and find them in models and charts
  - ❑ describe the gross anatomical features of the kidney and identify them in figures, models, and specimens
  - ❑ describe the features of the nephron and locate them in figures and models
  - ❑ identify the renal corpuscle in a prepared microscopic specimen
- ❑ Prepare your materials:
  - ❑ model of the human torso (dissectible)
  - ❑ model of the kidney (frontal section)
  - ❑ preserved sheep kidney (double or triple injected, if available)
  - ❑ dissection tools and trays
  - ❑ model of a nephron and associated structures
  - ❑ microscope
  - ❑ prepared microslide: *kidney cortex c.s.*
  - ❑ computer setup with DISSECTIBLE HUMAN or similar human dissection program (optional)
- ❑ Read the directions and safety tips for this exercise *carefully* before starting any procedure.

HINT

Using the DISSECTIBLE HUMAN or similar computerized human dissection program, explore the human body and try to find the structures listed in this activity. Check them off in your Lab Report as you find them.

A. The urinary plan

Study the layout of the urinary system by locating these features in a dissectible model of the human torso:

❑ 1 The left and right **kidneys** are located behind the peritoneum, along the posterior abdominal wall (Figure 47-1, *B*). Locate these kidney features:
- ❑ **Renal fat pad**—Tissue that surrounds and protects each kidney (not shown in all models)
- ❑ **Renal capsule**—The fibrous outer wall of the kidney
- ❑ **Hilum**—An indentation on the medial side of each kidney where vessels and nerves enter or exit

❑ 2 The **ureter** is a muscular tube that exits each kidney at the hilum and extends inferiorly to the pelvic cavity.

❑ 3 The **urinary bladder** is a collapsible, muscular sac for the temporary storage of urine. The two ureters enter on each side of the posterior floor of the bladder.

❑ 4 The **urethra** is a muscular tube that extends from the anterior floor of the bladder to the outside of the body. In the female, it is a short tube that ends just anterior to the vagina. In the male, it is much longer, extending all the way through the penis. In the male, it conducts semen and urine.

Urine is formed in each kidney and is conducted through the ureters to the bladder. When the bladder is full and it is convenient, **urinary sphincters** that control flow through the urethra relax and allow urine to exit the body.

B. The kidney model

Locate these features of the human kidney on a model (or chart) of a frontal section:

❑ 1 Locate the **hilum** and **renal capsule** from this perspective.

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❑ 2 Identify these structures located just within the hilum:
- ❑ **Renal sinus**—A fat-filled cavity
- ❑ **Renal pelvis**—A wide section of the urinary channel, distal to the ureter
- ❑ **Calyces**—Branches of the pelvis that extend from the kidney tissue proper

❑ 3 The kidney tissue proper is divided into an outer **cortex** and an inner **medulla,** as is the tissue of many organs. **Renal pyramids** are cone-shaped sections of tissue lying mostly within the medulla. Each appears as a triangle in a frontal section. Each is composed of collecting ducts that conduct urine toward its tip (papilla), which is surrounded by the end of a calyx.

Urine formed by the kidney is conducted through the collecting ducts of the renal pyramids to the calyces. The calyces fuse to form the large renal pyramid. As urine is conducted out of the kidney through the hilum, the urinary channel narrows to form the ureter.

❑ 4 Identify these features of the renal arterial supply (Figure 47-2):
- ❑ **Renal artery**—A branch of the abdominal aorta that enters the hilum and extends through the renal sinus
- ❑ **Interlobar arteries**—Branches of the renal arteries that extend outward through the tissue between the pyramids
- ❑ **Arcuate arteries**—Branches of the interlobar arteries that turn to extend between the cortex and medulla
- ❑ **Interlobular arteries**—Branches of the arcuate arteries that extend outward into the cortex
- ❑ **Afferent arterioles**—Small arteries that arise from branches of interlobular arteries, each one extending to a glomerulus
- ❑ **Glomerular capillaries**—Capillaries that arise from an afferent arteriole and form a ball or small capillary bed called a **glomerulus**

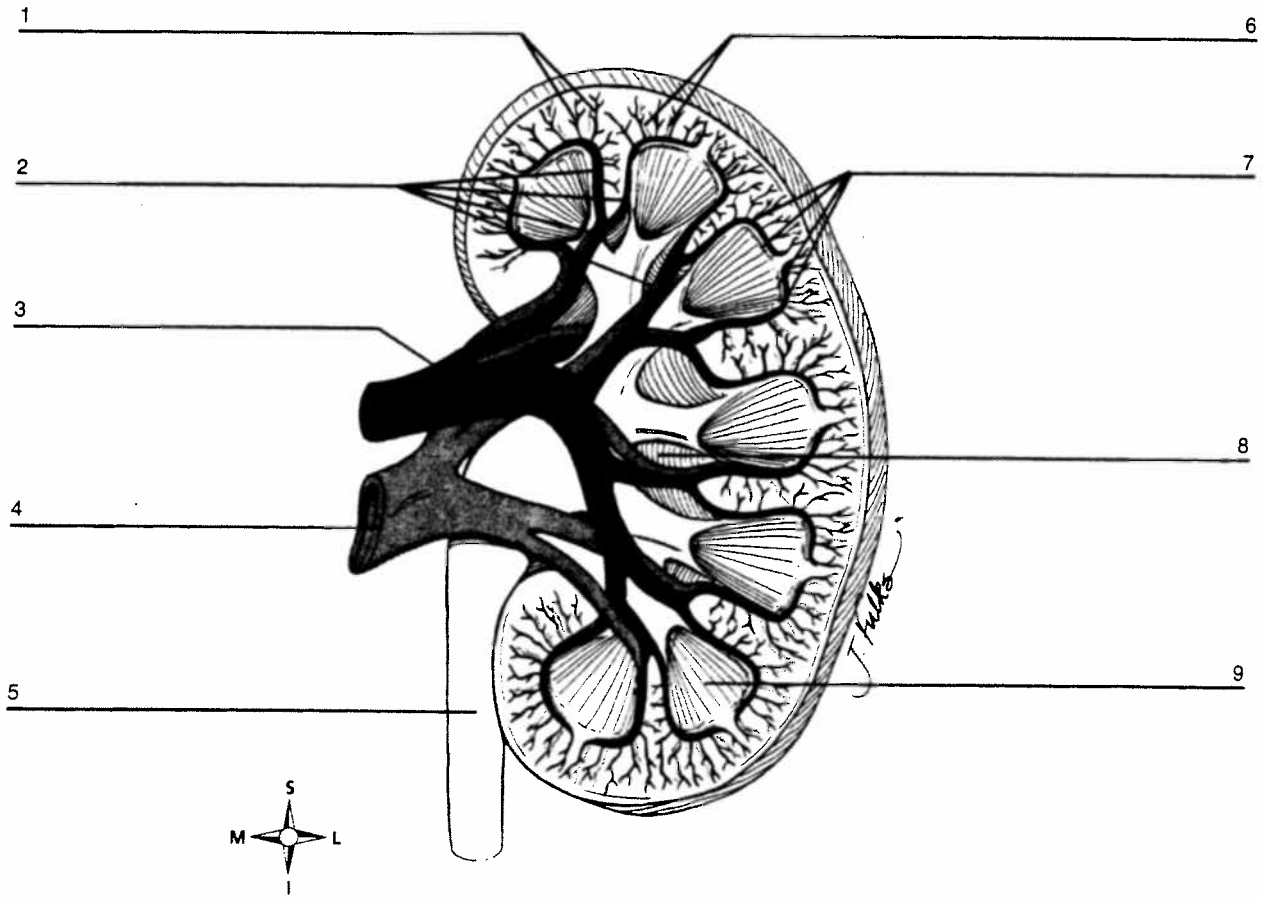

Figure 47-2 Circulation of blood through the kidney. Identify the renal blood vessels indicated on the lines provided and on the blanks in the Lab Report at the end of this exercise.

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❑ 5 After a brief detour, the venous network of the kidney parallels the arterial network, as you may expect:
- ❑ **Efferent arterioles**—Each extending from a glomerulus
- ❑ **Peritubular capillaries**—Small capillary beds that each arise from an efferent arteriole (a network of peritubular capillaries surrounds each *nephron*, the tubular, microscopic unit of the kidney)
- ❑ **Interlobular veins**
- ❑ **Arcuate veins**
- ❑ **Interlobar veins**
- ❑ **Renal veins**—Blood vessels that extend through the renal sinus, out the hilum, to drain into the inferior vena cava

C. The sheep kidney

SAFETY FIRST!
Observe the usual precautions when dissecting preserved specimens. Be sure to follow the safety advice that accompanies the preservative used in your specimen. Avoid injury with the dissection tools. Use safety goggles to avoid injury during dissections.

The sheep kidney is similar to the human kidney and makes an ideal specimen for study.

❑ 1 Examine the external aspect of your specimen. Identify as many parts of the kidney as you can. Refer to Activities A and B if you have trouble. You may have to remove some of the renal fat pad.

❑ 2 Use a long knife or scalpel to cut a section, dividing the kidney into roughly equal dorsal and ventral portions. Try to identify as many features as you can.

HINT
Double-injected specimens have red latex injected into the arteries and blue latex injected into the veins. Triple-injected specimens also have yellow latex injected into the urinary channels and tubules. You may be able to see some of the finer detail visible in an injected specimen by using a hand lens or a dissection microscope.

D. The nephron model

The functional units of the kidney are the tiny tubules called **nephrons** (Figure 47-3). The nephrons carry out the three basic processes that accomplish the kidney's function, forming *urine* as they do so: **filtration, tubular reabsorption,** and **tubular secretion.** Material from the blood is filtered into the beginning of the nephron. As the *filtrate* moves along the nephron tubule, some substances are reabsorbed into the blood and some additional substances are secreted from the blood into the filtrate. The urine thus produced is channeled to collecting ducts, which drain it from the kidney. Locate the main features of the nephron and associated structures in a model or chart.

❑ 1 The **renal corpuscle** is the roughly spherical structure at the beginning of the nephron. The inner portion of the renal corpuscle is the **glomerulus,** a ball of glomerular capillaries. Surrounding the glomerulus is the double-walled **Bowman's capsule.** Identify the afferent and efferent arterioles in the model. Can you trace their paths into the renal corpuscle, out, then to the peritubular capillaries?

❑ 2 The **proximal convoluted tubule** is a narrow channel proceeding from the Bowman's capsule of the renal corpuscle. It is *convoluted*, meaning that it is coiled.

❑ 3 Filtrate formed in the Bowman's capsule flows through the proximal convoluted tubule and into the **loop of Henle.** Anatomically, the loop is a continuation of the proximal tubule. In many nephrons, the **descending limb** of the loop dips far down into the medulla, turns, and returns as the **ascending limb** to the cortex.

❑ 4 Filtrate flows from the ascending limb of the loop of Henle into the **distal convoluted tubule.** The filtrate is emptied into a **collecting duct,** a tubule that collects urine from many nephrons and conducts it through a renal pyramid to a calyx. Eventually, the urine is voided during **urination** or **micturition.**

❑ 5 Your model may represent a nephron whose distal convoluted tubule passes between the afferent arteriole and efferent arteriole, near the renal corpuscle. If so, you may notice that the afferent arteriole wall and distal tubule wall form a specialized structure where they meet. This structure is called the **juxtaglomerular apparatus.**

Juxtaglomerular means "near the glomerulus." The juxtaglomerular apparatus secretes **renin,** an enzyme that catalyzes the conversion of *angiotensinogen* to *angiotensin I.* This begins a series of steps that helps regulate blood pressure.

E. Microscopic specimen

Obtain a prepared microscopic specimen of a cross section of renal cortical tissue (Figure 47-4). Scan it under low power first and locate one or more renal corpuscles, easily identifiable dark circles. Switch to high power and try to identify these features:

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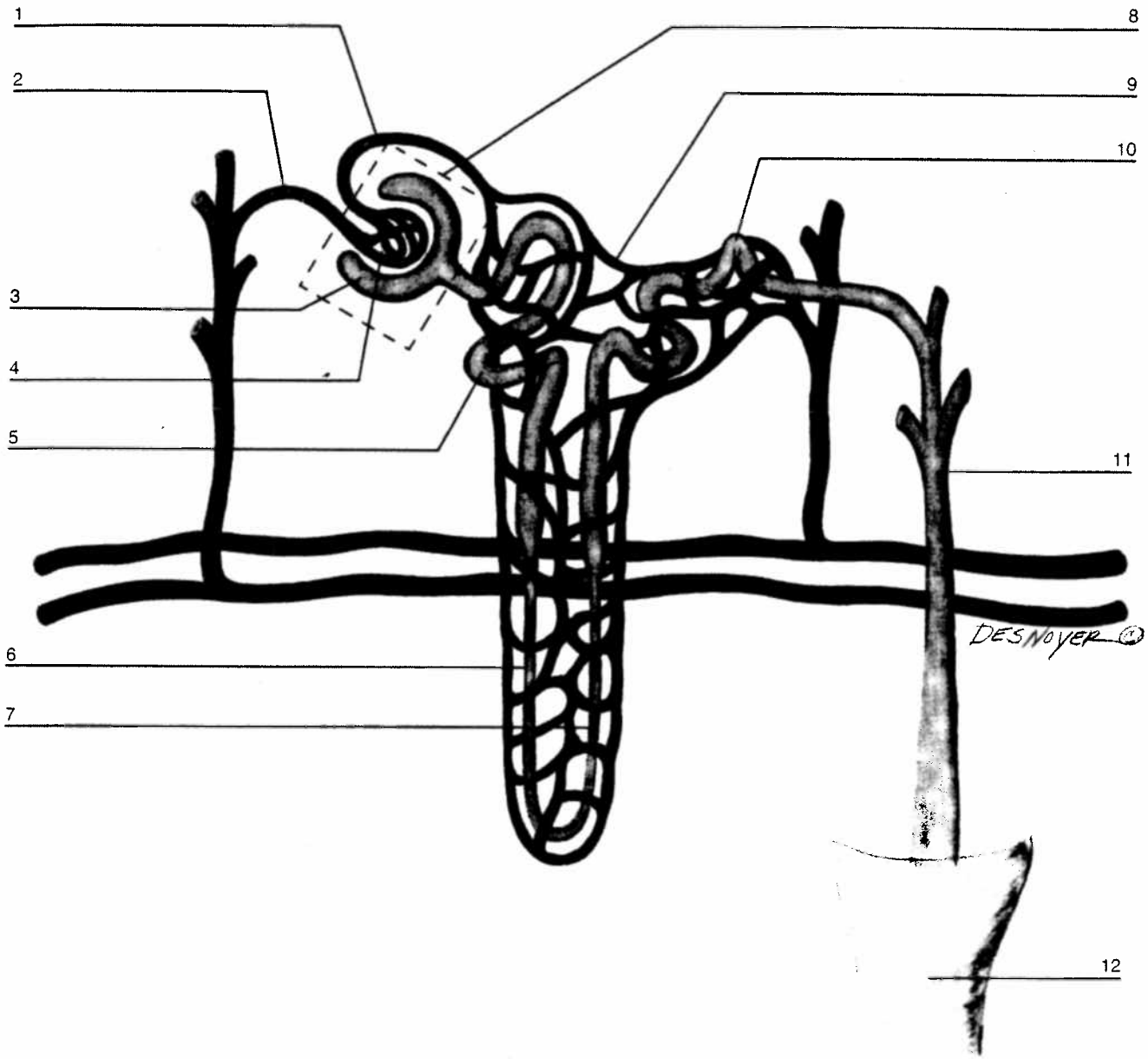


Figure 47-3 A nephron, the basic function unit of the kidney. Label the parts of the nephron indicated on the lines provided and on the blanks in the Lab Report at the end of this exercise.

SAFETY FIRST!
Observe the usual precautions when using the microscope and a prepared slide.

❑ 1 The glomerulus is the dark region forming the center of the renal corpuscle. It is a network of glomerular capillaries.

❑ 2 The Bowman's capsule is seen as a very thin white or light area surrounding the glomerulus. Actually, the *lumen* of the capsule appears white. The parietal wall of the Bowman's capsule is composed of simple squamous epithelium, which can sometimes be distinguished. The visceral wall of the Bowman's capsule is composed of specialized epithelial cells called **podocytes.** Podocytes have extensions that wrap around the capillary walls to form a filtration membrane. You will not be able to distinguish podocytes in your specimen.

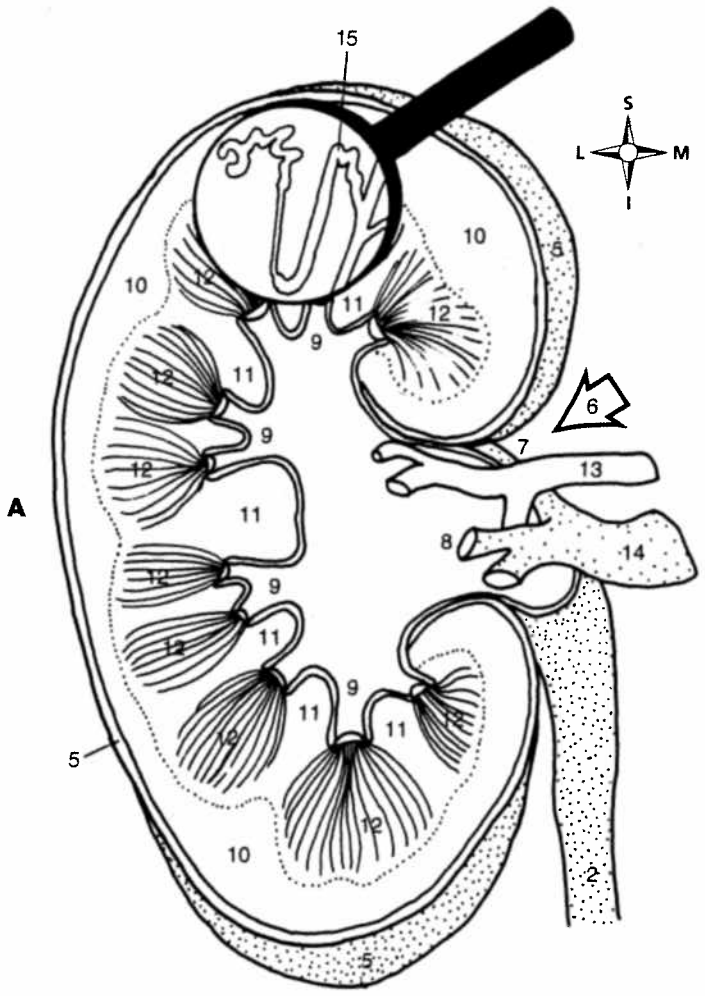
HINT
Plate 80 in the LABORATORY REFERENCE shows a color micrograph of the renal corpuscle.

COLORING EXERCISE

Using colored pens or pencils, shade in the figures and accompanying labels in contrasting colors of your choice as indicated by the red numerals.

The Urinary System

KIDNEY **1**
URETER **2**
URINARY BLADDER **3**
URETHRA **4**
RENAL CAPSULE **5**
HILUM **6**
RENAL SINUS **7**
RENAL PELVIS **8**
CALYCES **9**
RENAL CORTEX **10**
RENAL MEDULLA **11**
RENAL PYRAMIDS **12**
RENAL ARTERY **13**
RENAL VEIN **14**
NEPHRON **15**



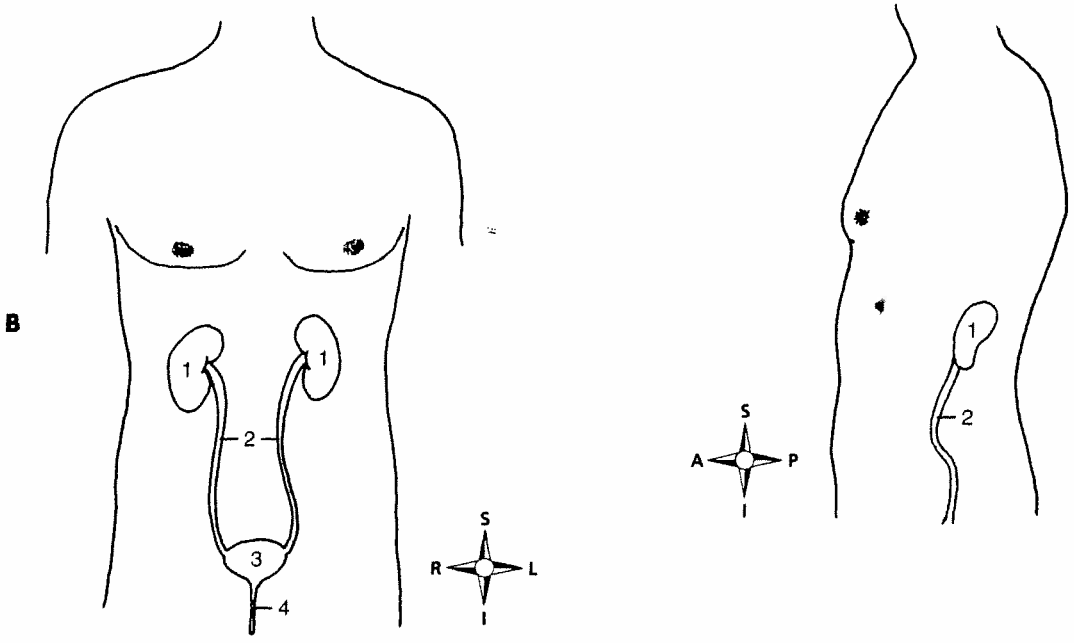


Figure 47-1 **A,** Internal structure of the kidney. **B,** Structures of the urinary system.

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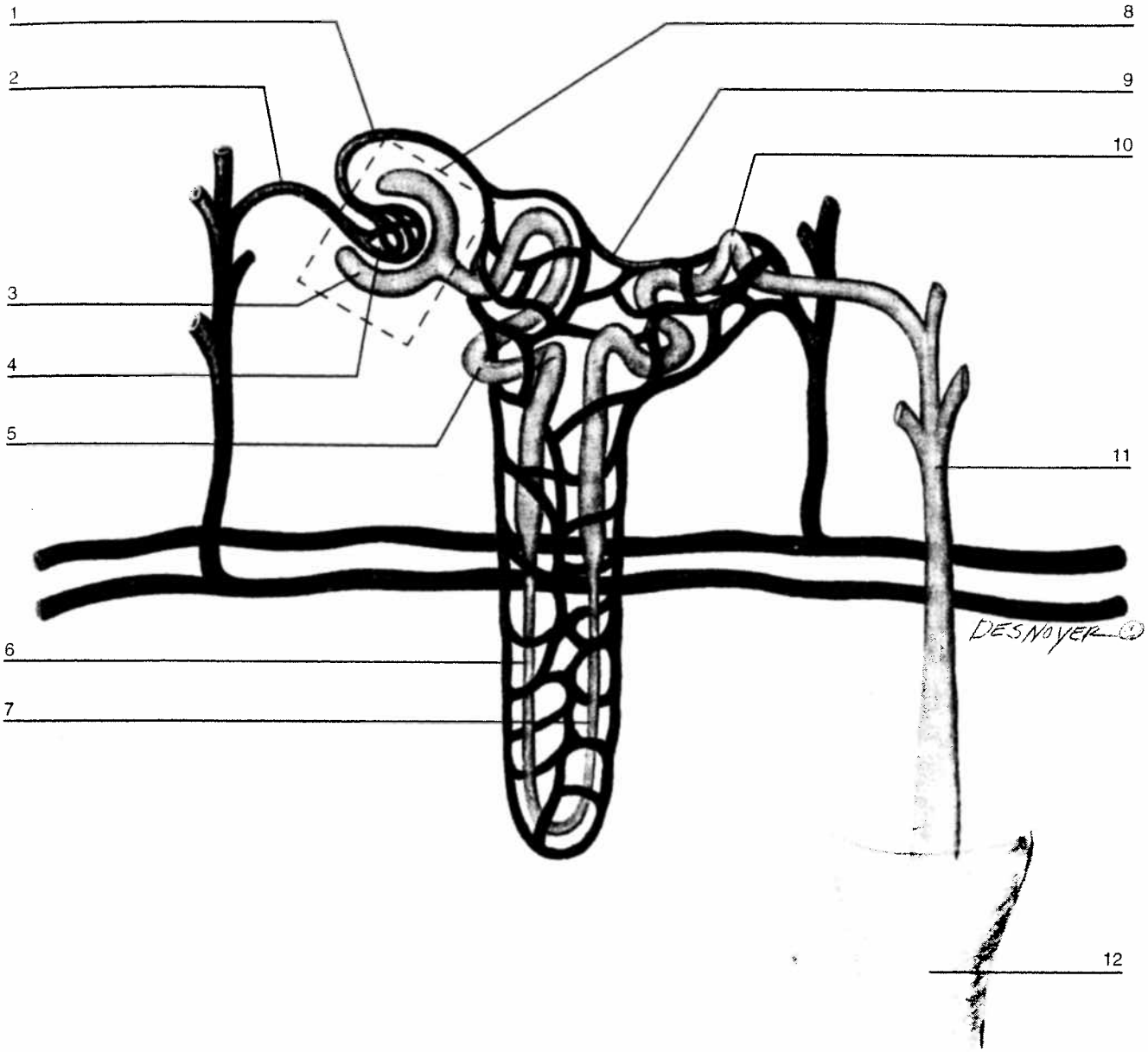

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❑ **1** The glomerulus is the dark region forming the center of the renal corpuscle. It is a network of glomerular capillaries.

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HINT
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Name: _____ **Date:** _____ **Section:** _____

LAB REPORT 47

Urinary Structures

Structure	Human	Sheep	Computer Simulation	Function(s)
Kidney	❑	❑	❑	
Renal capsule	❑	❑	❑	
Hilum	❑	❑	❑	
Ureter	❑	❑	❑	
Urinary bladder			❑	
Urethra			❑	
Renal sinus	❑	❑	❑	
Renal pelvis	❑	❑	❑	
Calyces	❑	❑	❑	
Renal cortex	❑	❑	❑	
Renal medulla	❑	❑	❑	
Renal pyramids	❑	❑	❑	
Renal artery, vein	❑	❑	❑	
Interlobar arteries, veins	❑	❑		
Arcuate arteries, veins	❑	❑		
Interlobular arteries, veins	❑	❑		
Afferent arteriole	❑	❑		
Glomerulus	❑	❑		
Efferent arteriole	❑	❑		
Peritubular capillaries	❑			
Renal corpuscle	❑			
Bowman's capsule	❑			
Proximal convoluted tubules	❑			
Loop of Henle: descending limb, ascending limb	❑			
Distal convoluted tubule	❑			
Collecting duct	❑			
Juxtaglomerular apparatus				

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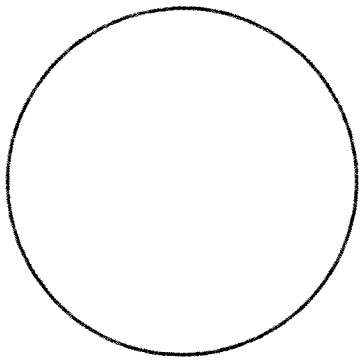
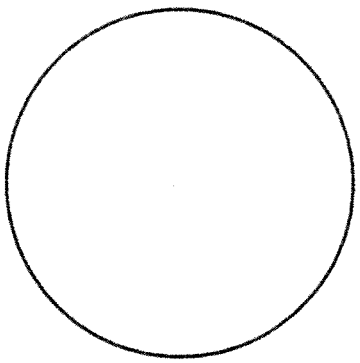


Specimen: *renal cortex c.s.*

Total Magnification: _____



Specimen: *renal cortex c.s.*

Total Magnification: _____

Figure 47-2

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____

Figure 47-3

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
0. _____
1. _____
2. _____

Put in Order

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

Fill-in

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Put in Order (arrange these structures in the order in which substances flow through the urinary system, beginning with the site of filtration)

ascending limb of the loop of Henle
Bowman's capsule
calyces
collecting duct
descending limb of the loop of Henle
distal convoluted tubule
proximal convoluted tubule
renal pelvis
ureter
urethra
urinary bladder

Fill-in (complete each statement with the correct term)

1. The ___?___ is a fat-filled cavity just inside the kidney's hilum.
2. The renal ___?___ are branches of the renal pelvis.
3. The ___?___ is a muscular tube extending from the renal pelvis to the urinary bladder.
4. The three basic processes observed in the nephron are filtration, tubular reabsorption, and tubular ___?___.
5. The ___?___ conducts blood into the glomerular capillaries.
6. The ___?___ conducts blood into the kidney.
7. The ___?___ capillaries surround the tubules of the nephron.
8. The inner tissue of the kidney is termed the renal ___?___.
9. The ___?___ apparatus secretes the enzyme renin.
10. The collecting ducts converge as they extend toward the calyces, forming the renal ___?___.

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