Chapter 17
Urinary System

Introduction
A. The urinary system consists of two kidneys that filter the blood, two ureters, a urinary bladder, and a urethra to convey waste substances to the outside.
Kidneys
A. The kidney is a reddish brown, bean-shaped organ 12 centimeters long; it is enclosed in a tough, fibrous capsule.

B. Location of the Kidneys
1. The kidneys are positioned retroperitoneally on either side of the vertebral column between the twelfth thoracic and third lumbar vertebrae, with the left kidney slightly higher than the right.
2. Two distinct regions are found within the kidney: a renal medulla and a renal cortex.
   a. The renal medulla houses tubes leading to the papillae.
   b. The renal cortex contains the nephrons, the functional units of the kidney.

C. Kidney Functions
   1. The kidneys function to regulate the volume, composition, and pH of body fluids and remove metabolic wastes from the blood in the process.
   2. The kidneys also help control the rate of red blood cell formation by secreting erythropoietin, and regulate blood pressure.

D. Nephrons
   1. Nephron Structure
      a. A kidney contains one million nephrons, each of which consists of a renal corpuscle and a renal tubule.
      b. The renal corpuscle is the filtering portion of the nephron; it is made up of a ball of capillaries called the glomerulus and a glomerular capsule that receives the filtrate.
c. The renal tubule leads away from the glomerular capsule and first becomes a highly coiled proximal convoluted tubule, then leads to the nephron loop, and finally to the distal convoluted tubule.

d. Several distal convoluted tubules join to become a collecting duct.

Urine Formation

A. Urine formation involves glomerular filtration, tubular reabsorption, and tubular secretion.

B. Glomerular Filtration

1. Urine formation begins when the fluid portion of the blood is filtered by the glomerulus and enters the glomerular capsule as glomerular filtrate.
F. Tubular Reabsorption
   1. Changes in the fluid composition from the time glomerular filtrate is formed when urine arrives at the collecting duct are largely the result of tubular reabsorption of selected substances.
   2. Most of the reabsorption occurs in the proximal convoluted tubule.
   3. Carrier proteins have a limited transport capacity, so excessive amounts of a substance will be excreted into the urine.

G. Sodium and Water Reabsorption
   1. Sodium ions are reabsorbed by active transport, and negatively charged ions follow passively (passive transport).
   2. As sodium is reabsorbed, water follows by osmosis.

H. Tubular Secretion
   1. Tubular secretion transports certain substances from the plasma into the renal tubule.
I. Urine Composition
   1. Urine composition varies from time to time and reflects the amounts of water and solutes that the kidneys eliminate to maintain homeostasis.
   2. Urine is 95% water, and also contains urea, uric acid, a trace of amino acids, and electrolytes.

Urine Elimination
A. After forming in the nephrons, urine passes from the collecting ducts to the renal papillae, then to the minor and major calyces, and out the renal pelvis to the ureters, urinary bladder, and finally to the urethra, which conveys urine to the outside.
B. Ureters
1. The **ureters** are muscular tubes extending from the kidneys to the base of the urinary bladder.
2. Muscular peristaltic waves convey urine to the urinary bladder where it passes through a flaplike valve in the mucous membrane of the urinary bladder.

C. Urinary Bladder
1. The **urinary bladder** is a hollow, distensible, muscular organ lying in the pelvic cavity.
2. The internal floor of the bladder includes the **trigone**, which is composed of the openings of the two ureters and the urethra.
D. Micturition
1. Urine leaves the bladder by the micturation reflex.
2. The detrusor muscle contracts and the external urethral sphincter (in the urogenital diaphragm) must also relax.

3. Stretching of the urinary bladder triggers the micturation reflex center located in the sacral portion of the spinal cord.
4. Return parasympathetic impulses cause the detrusor muscle to contract in waves, and an urge to urinate is sensed.

5. When these contractions become strong enough, the internal urethral sphincter is forced open.
6. The external urethral sphincter is composed of skeletal muscle and is under conscious control.
E. Urethra
   1. The urethra is a tube that conveys urine from the urinary bladder to the outside via the external urethral orifice.
   2. It is a muscular tube with urethral glands that secrete mucus into the urethral canal.