to the blood in the peritubular capillaries. Most reabsorption occurs in the proximal tubule. Almost all glucose and amino acids are reabsorbed; about 80% of water, sodium, potassium, chloride, and most other substances is reabsorbed. As a result, about 20% of the glomerular filtrate enters the loop of Henle. In the descending limb of the loop of Henle, water is reabsorbed; in the ascending limb, sodium is reabsorbed. A large fraction of the total amount of sodium (up to 30%) filtered by the glomeruli is reabsorbed in the loop of Henle. Additional sodium is reabsorbed in the distal tubule, primarily by the exchange of sodium ions for potassium ions secreted by epithelial cells of tubular walls. Final reabsorption of water occurs in the distal tubule and small collecting tubules. The remaining water and solutes are now appropriately called *urine*.

Antidiuretic hormone from the posterior pituitary gland promotes reabsorption of water from the distal tubules and the collecting ducts of the kidneys. This conserves water needed by the body and produces more concentrated urine. Aldosterone, a hormone from the adrenal cortex, promotes sodium–potassium exchange mainly in the distal tubule and collecting ducts. Thus, aldosterone promotes sodium reabsorption and potassium loss.

Tubular Secretion

The term *secretion*, in relation to renal function, indicates movement of substances from blood in the peritubular capillaries to glomerular filtrate flowing through the renal tubules. Secretion occurs in the proximal and distal tubules, across the epithelial cells that line the tubules. In the proximal tubule, uric acid, creatinine, hydrogen ions, and ammonia are secreted; in the distal tubule, potassium ions, hydrogen ions, and ammonia are secreted. Secretion of hydrogen ions is important in maintaining acid–base balance in body fluids.

ALTERATIONS IN RENAL FUNCTION

Many clinical conditions alter renal function. In some conditions, excessive amounts of substances (eg, sodium and water) are retained; in others, needed substances (eg, potassium, proteins) are eliminated. These conditions include cardiovascular, renal, hepatic, and other disorders that may be managed with diuretic drugs.

Edema

Edema is the excessive accumulation of fluid in body tissues. It is a symptom of many disease processes and may occur in any part of the body. Additional characteristics include the following:

1. Edema formation results from one or more of the following mechanisms that allow fluid to leave the bloodstream (intravascular compartment) and enter interstitial (third) spaces.
   a. Increased capillary permeability occurs as part of the response to tissue injury. Thus, edema may occur with burns and trauma or allergic and inflammatory reactions.
   b. Increased capillary hydrostatic pressure results from a sequence of events in which increased blood volume (from fluid overload or sodium and water retention) or obstruction of venous blood flow causes a high venous pressure and a high capillary pressure. This is the primary mechanism for edema formation in heart failure, pulmonary edema, and renal failure.
   c. Decreased plasma oncotic pressure may occur with decreased synthesis of plasma proteins (caused by liver disease or malnutrition) or increased loss of plasma proteins (caused by burn injuries or the nephrotic syndrome). Plasma proteins are important in keeping fluids within the bloodstream. When plasma proteins are lacking, fluid seeps through the capillaries and accumulates in tissues.
2. Edema interferes with blood flow to tissues. Thus, it interferes with delivery of oxygen and nutrients and removal of metabolic waste products. If severe, edema may distort body features, impair movement, and interfere with activities of daily living.
3. Specific manifestations of edema are determined by its location and extent. A common type of localized edema occurs in the feet and ankles (dependent edema), especially with prolonged sitting or standing. A less common but more severe type of localized edema is pulmonary edema, a life-threatening condition that occurs with circulatory overload (eg, of intravenous [IV] fluids or blood transfusions) or acute heart failure. Generalized massive edema (anasarca) interferes with the functions of many body organs and tissues.

DIURETIC DRUGS

Diuretic drugs act on the kidneys to decrease reabsorption of sodium, chloride, water, and other substances. Major subclasses are the thiazides and related diuretics, loop diuretics, and potassium-sparing diuretics, which act at different sites in the nephron (Fig. 56–2).

Major clinical indications for diuretics are edema, heart failure, and hypertension. In edematous states, diuretics mobilize tissue fluids by decreasing plasma volume. In hypertension, the exact mechanism by which diuretics lower blood pressure is unknown, but antihypertensive action is usually attributed to sodium depletion. Initially, diuretics decrease blood volume and cardiac output. With chronic use, cardiac output returns to normal, but there is a persistent decrease in plasma volume and peripheral vascular resistance. Sodium depletion may have a vasodilating effect on arterioles.