LEARNING OBJECTIVES

1. Describe the gross and microscopic structure of the kidney.
2. Discuss the various functions of the normal kidney.
3. Define and discuss the various renal syndromes, such as acute kidney injury, chronic kidney disease, nephrotic and nephritic syndromes, tubulointerstitial diseases, and vascular diseases of the kidney.

Summary

The kidneys are paired organs located retroperitoneally in the lumbar region and perform three major functions: (i) maintenance of fluid and acid–base balance; (ii) removal of nitrogenous waste products; and (iii) synthesis of hormones, such as renin, erythropoietin, and active vitamin D$_3$ (calcitriol). The functional unit of the kidney is the nephron, which consists of a renal corpuscle, the proximal tubule, the loop of Henle, the distal tubule, and the collecting duct. The renal corpuscle consists of the glomerulus and Bowman’s capsule. Plasma is filtered in the glomerulus to form protein-free ultrafiltrate. About 60% of this ultrafiltrate is reabsorbed in the proximal tubule. The loop of Henle participates in countercurrent multiplication of urine concentration. The distal tubule generates hypotonic fluid in the tubular lumen, causing hypertonic medullary interstitium. The collecting duct plays an important role in potassium (K$^+$) secretion, urinary acidification, and water reabsorption in the presence of antidiuretic hormone. When the structure of the kidney is disturbed by a pathologic
process, its functions are altered. These changes in the kidney result in an increase in serum creatinine levels (e.g., acute kidney injury, chronic kidney disease, or tubulointerstitial disease), proteinuria (e.g., nephrotic syndrome), and hematuria (e.g., glomerulonephritis). Also renal vasculature is affected, causing hypertension and thrombotic microangiopathies.

**Key Words:** Nephron; glomerulus; renal function; chronic kidney disease; nephrotic syndrome; nephritic syndrome.

1. **INTRODUCTION**

The kidneys perform three major functions (1). As regulatory organs, the kidneys precisely control the composition and volume of the body fluids and maintain acid–base balance as well as blood pressure by varying the excretion of water and solutes. As excretory organs, the kidneys remove various nitrogenous metabolic end products in the urine. In general, the kidneys filter plasma in the glomerulus to form a protein-free ultrafiltrate. This ultrafiltrate passes through the various tubular segments where reabsorption of essential constituents and secretion of unwanted products occur. As endocrine organs, the kidneys produce important hormones, such as renin, erythropoietin, and active vitamin D₃ (calcitriol). In addition, the kidneys participate in the degradation of various endogenous and exogenous compounds. In order to understand these functions, it is essential to examine the gross and microscopic structure of the kidneys.

1.1. **Anatomy of the Kidney**

The kidneys are paired, bean-shaped structures located retroperitoneally in the lumbar region, one on either side of the vertebral column (1–3). The lateral edge of the kidney is convex, while the medial aspect is concave with a notch called the hilum. The hilum receives the blood and lymphatic vessels, the nerves, and the ureter. The hilum contains a cavity, the renal sinus, where the ureter expands to form the renal pelvis. The normal adult kidney is about 10-12 cm long, 5-7 cm wide, and 2-3 cm thick, and it weighs 125–170 g.

Each kidney is composed of the parenchyma and the collecting system. The parenchyma consists of an outer cortex and an inner medulla. The medulla is divided into an outer (toward the cortex) and an inner medulla (toward the pelvis). The collecting system includes the calyces, renal pelvis, and the ureters. The major calyces unite to form the renal pelvis. The renal pelvis drains into the ureter, which connects the kidney to the bladder.