a LANGE medical book

Vander's Renal Physiology

Tenth Edition

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To all our students

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Preface

In the many years since renowned renal physiologist Arthur Vander published the 1st edition of this book, a great deal has been learned about the detailed workings of the kidneys. While this has satisfied the curiosity of physiologists studying the kidneys, it has increased the burden on students who are trying the grasp the essentials. As authors of the more recent editions, our goal is to focus on the big picture, that is, what the kidneys do for the body and how they do it, presenting the fundamental aspects of renal function without overwhelming the reader with detail. Accordingly, we have surveyed recent research results and reviews in order to present the most up-to-date and accurate description of renal processes and function, all the while being cognizant of the needs of the student who is just beginning a study of the kidneys. The text of all chapters has been revised and several figures have also been revised for this edition.

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Renal Functions, Basic Processes, and Anatomy

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OBJECTIVES

- *State seven major functions of the kidneys.*
- *Define the balance concept and give examples.*
- *Define the gross structures and their interrelationships: renal pelvis, calyces, renal pyramids, renal medulla (inner and outer zones), renal cortex, and papilla.*
- *Define the components of the nephron-collecting duct system and their interrelationships: renal corpuscle, glomerulus, tubule, and collecting-duct system.*
- *Draw the relationship between glomerulus, Bowman's capsule, and the proximal tubule.*
- *Define juxtaglomerular apparatus and describe its three cell types; state the function of the granular cells.*
- *List the individual tubular segments in order; state the segments that comprise the proximal tubule, Henle's loop, and the distal nephron including the collecting-duct system; define principal cells and intercalated cells.*
- *Define the basic renal processes: glomerular filtration, tubular reabsorption, tubular secretion, and tubular production.*
- *Define renal metabolism of a substance and give examples.*

RENAL FUNCTIONS

The kidneys are multifunction biological machines that accomplish far more than their popularly known function, excretion of soluble waste. The kidneys do indeed excrete waste, for example, the end products of protein metabolism, and of course water, which constitutes almost the entire urinary volume. However, the kidneys are far from just physiological trash chutes leading to the bladder. Virtually everything that goes into the bladder is regulated by processes within the kidneys that add or subtract material, thereby controlling what is conserved or what is lost from the body.

The kidneys work cooperatively and interactively with many other organ systems to maintain body function. This chapter provides a brief account of renal

contains amounts of each substance necessary to maintain total body balance for each of the substances.

ANATOMY OF THE KIDNEYS AND URINARY SYSTEM

The operation of the kidneys is intimately connected to their structure. An understanding of renal function requires a grasp of the key aspects of both macroscopic and microscopic structures. Human kidneys are bean-shaped organs about the size of a fist. They are located just under the rib cage behind the peritoneal cavity close to the posterior abdominal wall, one on each side of the vertebral column (Figure 1–1). The rounded, outer convex surface of each kidney faces the side of the body. Covering the very external surface of the kidney is a thin connective tissue capsule (Figure 1–2). The indented surface, called the *hilum,* faces the spine. Each hilum is penetrated by blood vessels, nerves, and a ureter. The ureters bend down from the kidneys and extend approximately 30 cm to the bladder. Each ureter within a kidney is formed from several funnel-like structures called major *calyces*, which are themselves formed from minor calyces. The minor calyces fit over underlying cone-shaped renal tissue called *pyramids* (Figure 1–2). The tip of each pyramid is called a *papilla* and projects into a minor calyx. The calyces act as collecting cups for the urine formed by the renal tissue in the pyramids. The pyramids are arranged radially around the hilum, with the papillae pointing toward the hilum and the broad bases of the pyramids facing the convex surface of the kidney.

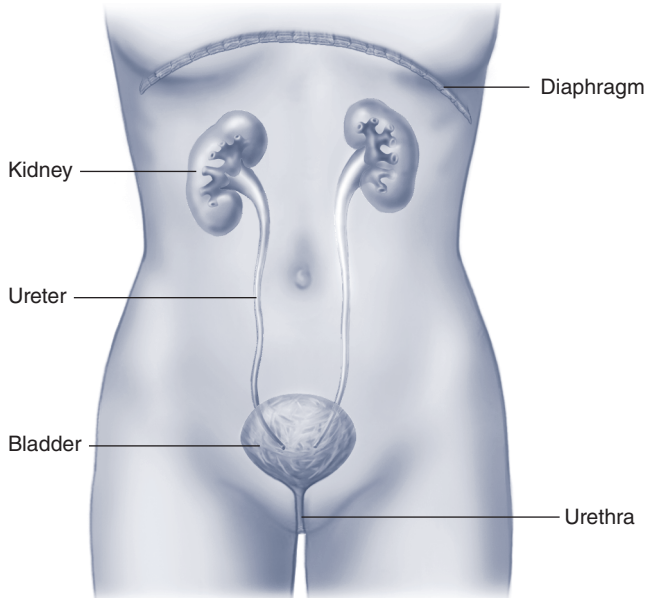

Figure 1–1. Urinary system in a female, indicating the location of the kidneys below the diaphragm and well above the bladder, which is connected to the kidneys via the ureters. (Reproduced with permission from Widmaier EP, Raff H, Strang KT. *Vander's Human Physiology.* 11th ed. New York: McGraw-Hill; 2008.)