RENAL DISORDERS

Mosby's Clinical Nursing Series

Dorothy J. Brundage

RENAL DISORDERS

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The authors and publisher have made a conscientious effort to ensure that the drug information and recommended dosages in this book are accurate and in accord with accepted standards at the time of publication. However, pharmacology is a rapidly changing science, so readers are advised to check the package insert provided by the manufacturer before administering any drug.

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PREFACE

Renal Disorders is the fifth volume in *Mosby's Clinical Nursing Series*, a new kind of resource for practicing nurses.

The *Series* is the result of the most elaborate market research ever undertaken by Mosby–Year Book, Inc. We first surveyed hundreds of working nurses to determine what kind of resources practicing nurses want in order to meet their advanced information needs. We then approached clinical specialists—proven authors and experts in 10 practice areas, from cardiovascular disease to immunology, and asked them to develop a common format that would meet the needs of nurses in practice, as specified by the survey respondents. This plan was then presented to nine focus groups composed of working nurses over a period of 18 months. The plan was refined between each group, and in the later stages we published a 32-page full-color sample so that detailed changes could be made to improve the physical layout and appearance of the book, section by section and page by page.

The result is a new genre of professional books for nursing professionals.

Renal Disorders begins with an innovative Color Atlas of Renal Anatomy and Physiology. This illustrated review is a collection of highly detailed full-color drawings designed to depict normal structure and function.

Chapter 2 is a pictoral guide to the nurse's assessment of the renal system. Clear, full-color photographs show proper position and technique in sharp detail, aided by concise instructions, rationales, and tips.

Chapter 3 presents the latest in diagnostic tests, again using full-color photographs of equipment, techniques, monitors, and output. A consistent format for each diagnostic procedure gives nurses information about the purpose of the test, indications and contraindications, and the nursing care associated with each test, including patient teaching.

Chapters 4 to 10 present the nursing care of patients experiencing renal failure (acute and chronic), infectious renal diseases, autoimmune disorders, renovascular diseases, metabolic disorders, cancer of the kidney, and obstructive and congenital disorders. Each disorder is presented in a format to meet your advanced practice needs. Information on pathophysiology answers questions nurses often have. A unique box alerting nurses to possible complications provides this information to health professionals in the best position to observe, respond to, and report dangerous changes in patient conditions. Definitive diagnostic tests and the physician's treatment plan are briefly reviewed to promote collaborative care among members of the health care team. Color plates in the front of the book highlight pathology of selected renal disorders.

Chapter 11 presents surgical and therapeutic procedures, focusing on the nursing care of patients undergoing procedures such as dialysis, surgery, transplantation, and extracorporeal shock-wave lithotripsy.

The heart of the book is the nursing care, presented according to the nursing process. These pages have a color border to make them easy to find and use on the unit. The nursing care is structured to integrate the five steps of the nursing process, centered around appropriate nursing diagnoses accepted by the North American Nursing Diagnosis Association (NANDA). The material can be used to develop individualized care plans quickly and accurately. By facilitating the development of individualized and authoritative care plans, this book can save you time to spend on direct patient care.

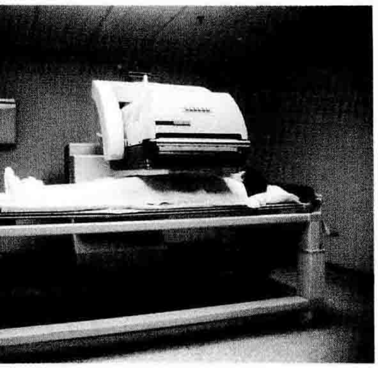
In response to requests from scores participating in our research, a distinctive feature of this book is its use in patient teaching. Background information on diseases and medical interventions enables nurses to answer with authority questions patients often ask. The illustrations in the book, particularly those in the Color Atlas and the chapter on Diagnostic Procedures, are specifically designed to support patient teaching. Chapter 12 consists of 12 Patient Teaching Guides that can be copied, distributed to patients and their families, and used for self-care after discharge. Patient teaching sections in each care plan provide nurses with check lists of concepts to teach, promoting this increasingly vital aspect of nursing care.

The book concludes with a concise guide to renal drugs that includes a table of dose adjustments of common drug groups when renal function is reduced. Following is a detailed appendix summarizing nutrition in renal disease. Inside the back cover is a resource section that directs you to organizations and other resources on renal health for nurses and patients.

This book is intended for medical-surgical nurses, who invariably care for patients with acute renal disorders. Critical care nurses in our survey and focus groups also expressed a need for the book. We expect that students will find the book an indispensable help in developing clinical skills and judgment in caring for patients with renal disorders, as it will also be for nurses returning to practice after a hiatus, nurses seeking advanced certification, and nurses transferring to medical-surgical or critical care settings.

We hope this book contributes to the advancement of professional nursing by serving as a first step toward a body of professional literature for nurses to call their own.

CONTENTS

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CHAPTER 1

Color Atlas of Renal Anatomy and Physiology

The renal system functions to excrete water-soluble waste products and to maintain the homeostasis of plasma water, electrolytes, and pH. Water-soluble blood constituents that can cross capillary walls filter into the nephrons, the functional units of the kidneys, for processing. After this filtrate has passed through the nephrons and collecting ducts, it is called urine. Nephrons process the filtrate by (1) reabsorbing the essential constituents of the plasma filtrate, (2) ignoring the unwanted constituents, and (3) adding other constituents of the plasma to the filtrate by secretion.

The nephrons' ability to maintain homeostasis depends on (1) the circulatory system, which must provide the kidneys with a sufficient volume of blood at the optimum pressure, and (2) the nervous and endocrine systems, which must detect a loss of homeostasis and adjust the intrinsic renal mechanisms appropriately.

ANATOMY OF THE KIDNEY

The two kidneys are attached by connective tissue and an extensive fat pad to the dorsal wall of the abdominal cavity. They lie outside the parietal layer of the peritoneum, level with the T12 and the L1-L3 vertebrae (Figure 1-1). The renal arteries, veins, nerves, lymph vessels, and ureters all enter or leave the kidney on the medial surface in the indented region called the renal sinus, or hilum (Figure 1-2). (For a picture of a normal kidney, see Color Plate 1, page x.)

The basic structure of the right kidney can be seen in a cross-section in Figure 1-3. The kidneys are enclosed by a strong membrane of white, fibrous connective tissue called the **capsule.** The outer layer of the kidney parenchyma is the **cortex,** which has a granular appearance because of the shape of the many renal corpuscles and convoluted tubules that it contains. The cortex surrounds the **medulla,** which has a fibrous appearance because of the loops of Henle and the collecting ducts of the nephron, which lie parallel to each other in the radial plane. The medulla is organized into **pyramids,** with **columns** of cortical tissue separating them close to the cortex and major and minor **calyces** separating them from the renal **pelvis.** Urine is collected by the pelvis and delivered to the **ureter.**

The **renal arteries** are short and wide to ensure that 20% to 25% of the resting cardiac output (approximately 1,200 ml per minute) passes through the kidneys (Figure 1-4). This is far more than is required to replace the oxygen used by the kidneys, because a larger amount of blood is needed to produce the large volume of filtrate required for homeostasis of the blood. Blood leaves in the renal veins, and lymph leaves in lymph vessels located close to the cortical-medullary junction.

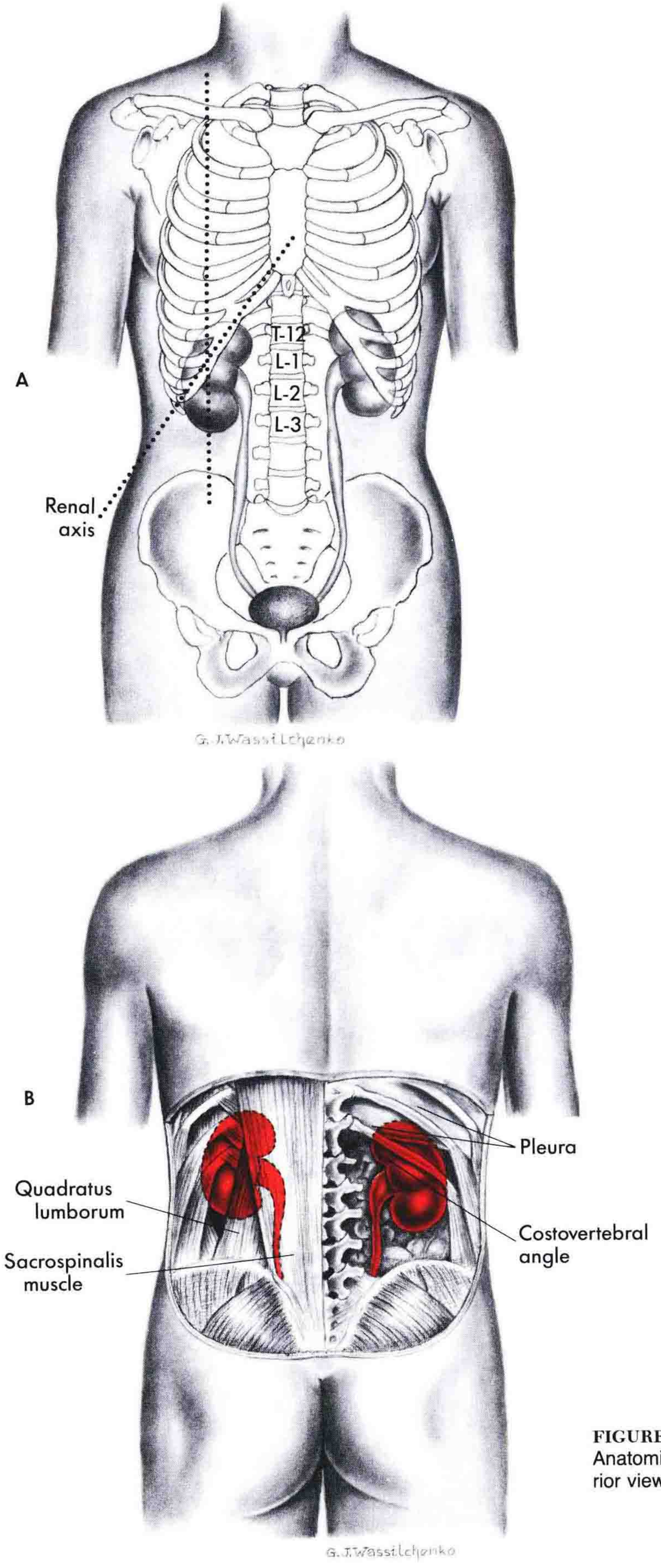

FIGURE 1-1
Anatomic relation of the kidneys to the spinal column. **A,** Anterior view. **B,** Posterior view. (From Thompson.[27])

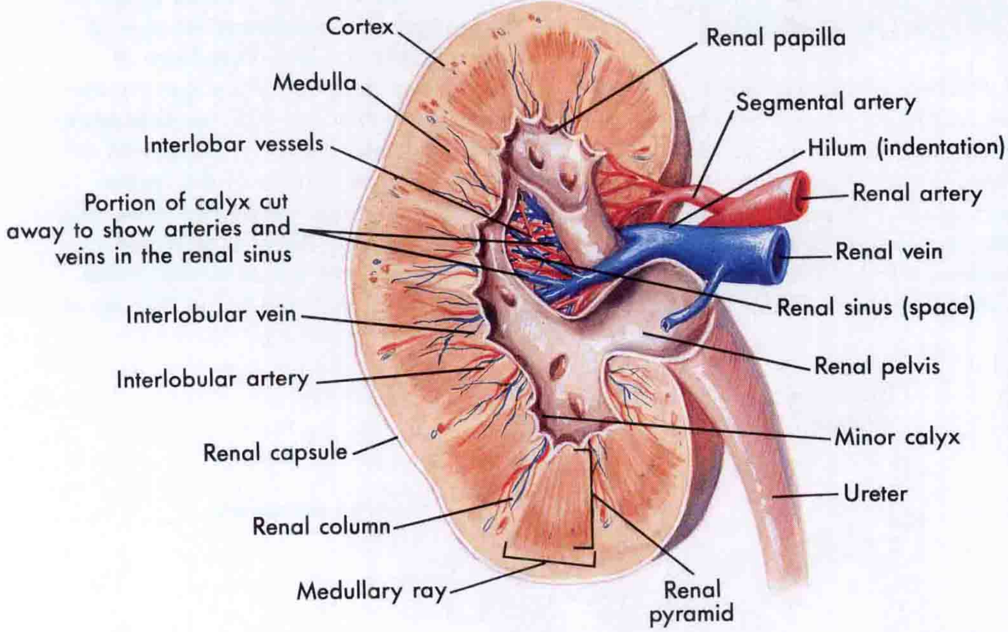

FIGURE 1-2
Longitudinal cross-section of the kidney showing blood supply. (From Seeley.[22])

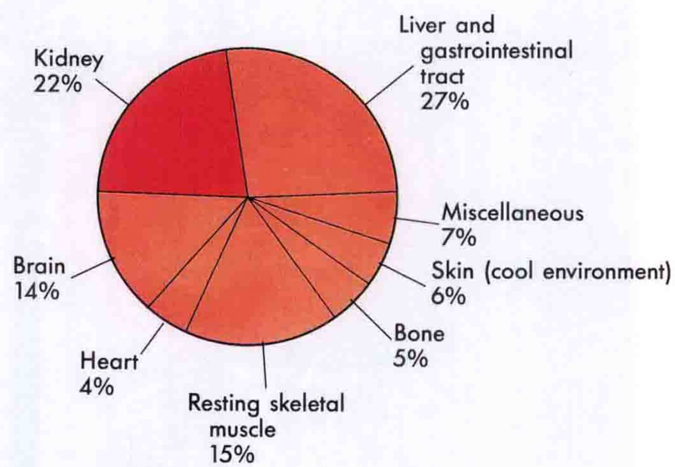

FIGURE 1-4
Proportion of the blood pumped into the aorta that flows through the kidneys compared with amounts flowing to other organs of an individual at rest.

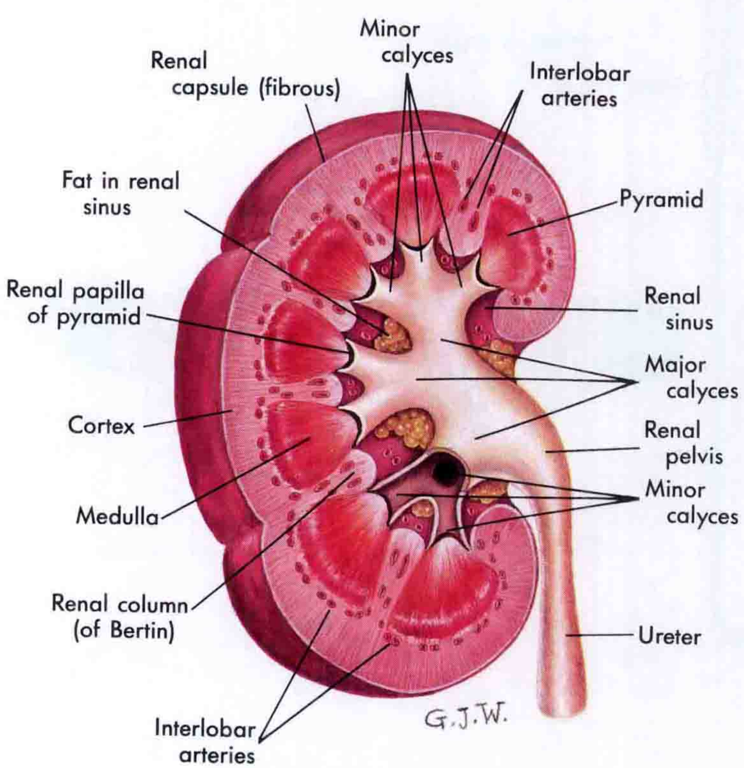

FIGURE 1-3
Cross-section of the kidney showing basic structures.

MICROSCOPIC STRUCTURE OF THE NEPHRONS

The structure of a typical nephron is shown in Figure 1-5. Filtrate flows through the different regions of the nephron in the following sequence: **Bowman's capsule**, the **proximal convoluted tubule**, the **loop of Henle**, and the **distal convoluted tubule.** The nephrons empty into **collecting ducts.** There are two types of nephrons: 20% of the nephrons (**juxtamedullary nephrons**) lie close to the medulla and have long loops of Henle that penetrate deep into the medulla; the remaining 80% (**cortical nephrons**) have short loops of Henle and are located almost entirely in the cortex.

Each nephron has its own **blood supply** (Figure 1-6). Blood is delivered by the **afferent arteriole** to the spherical knot of capillaries that lies in the cup of

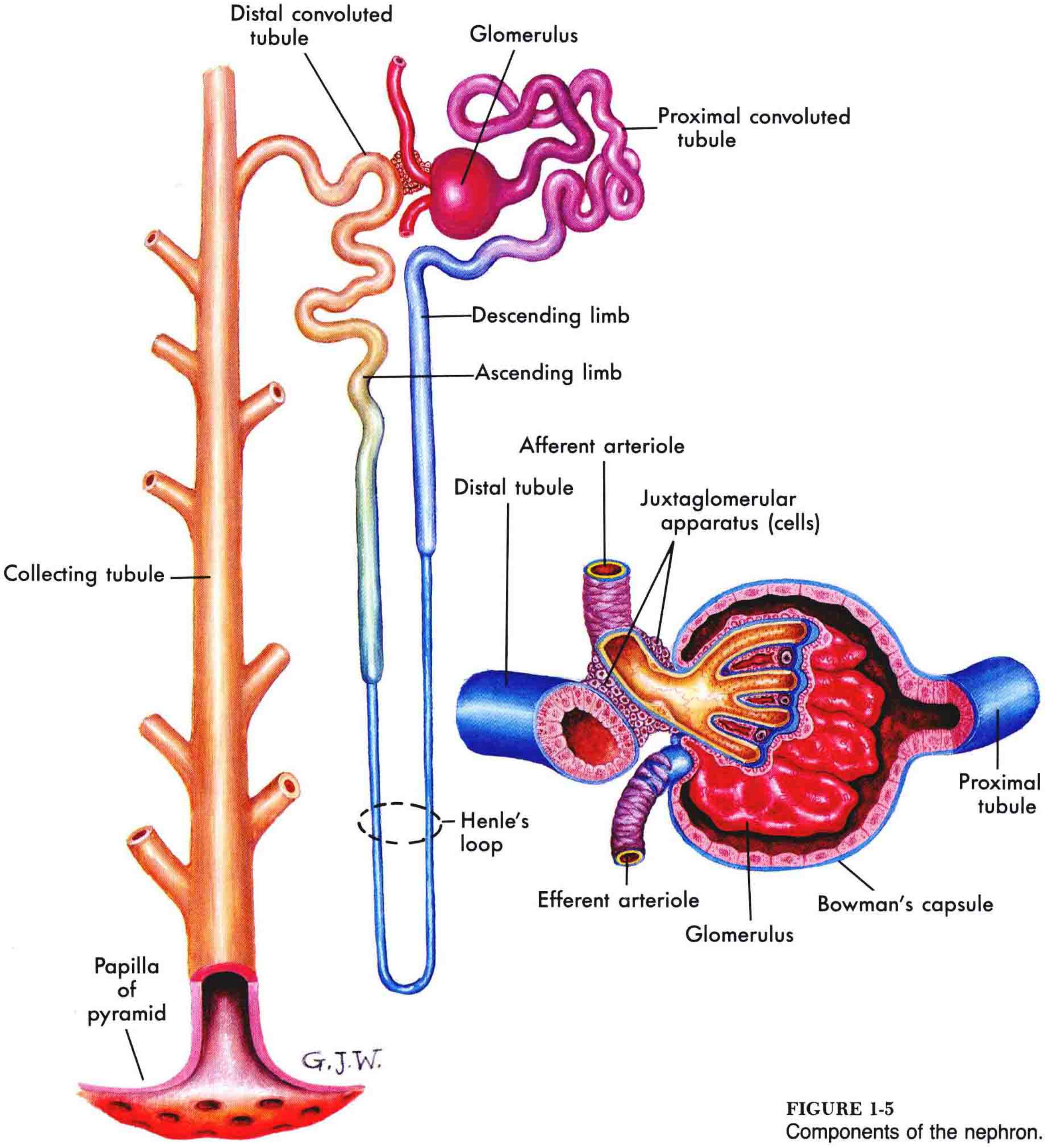

FIGURE 1-5
Components of the nephron.

Bowman's capsule and is called the **glomerulus.** From the glomerulus the blood flows into the **efferent arteriole,** which delivers it to the **peritubular capillaries** that follow the course of the nephron. The peritubular capillaries that loop into the medulla and back to the cortex with the loop of Henle are called the vasa recta. Blood leaves the peritubular capillaries in venules that direct the blood back to the general circulatory system.

A patch of the wall of the afferent arteriole is joined to a patch of the wall (macula densa) of the distal convoluted tubule. Together they form a structure called the **juxtaglomerular apparatus,** which monitors and controls the amount of filtrate processed by the nephron (Figure 1-7).

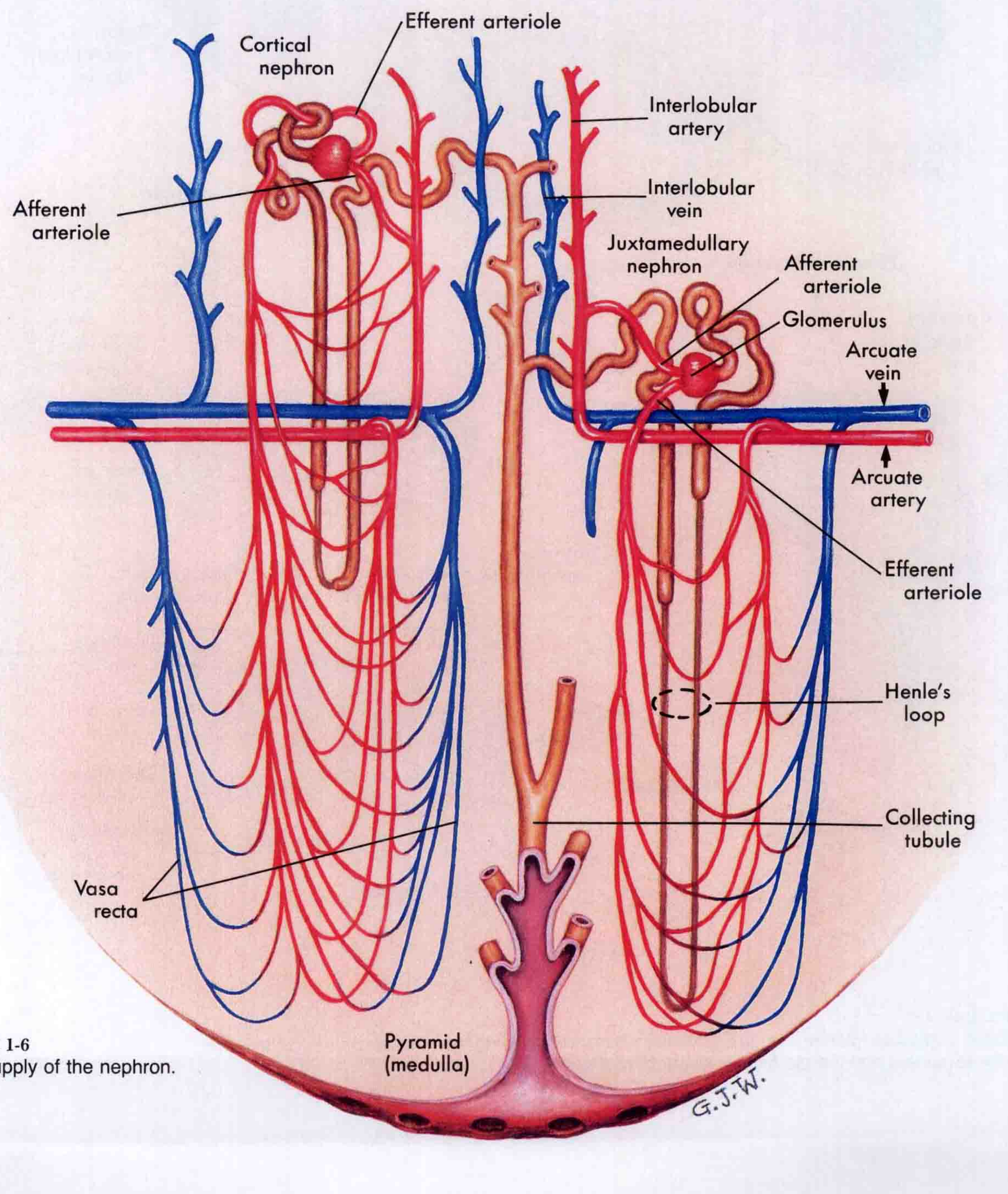

FIGURE 1-6
Blood supply of the nephron.

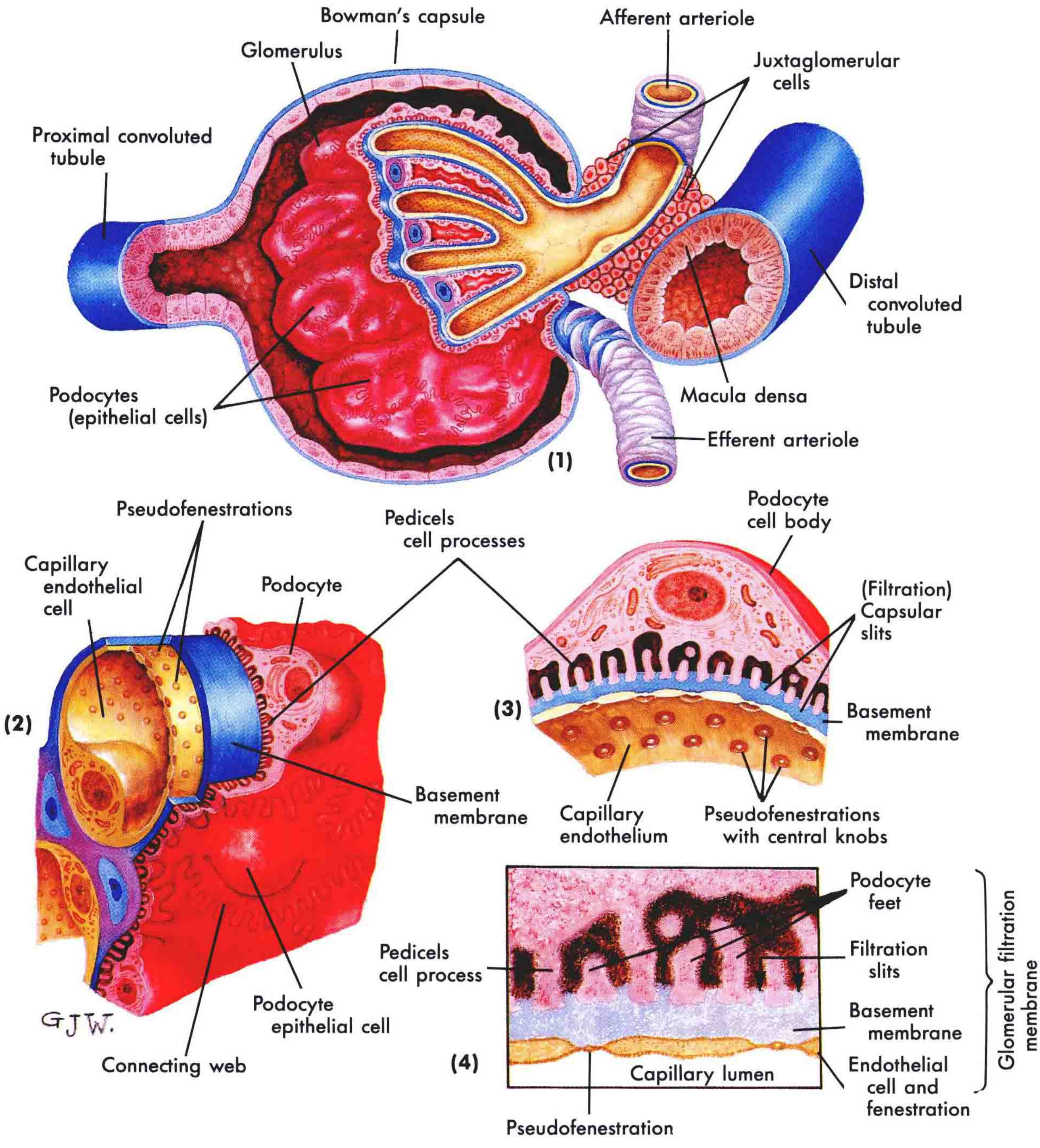

FIGURE 1-7
Renal corpuscle (glomerulus and Bowman's capsule) showing the location of the juxtaglomerular apparatus and the glomerular filtration membrane.

FUNCTIONS OF THE NEPHRONS AND COLLECTING DUCTS

Each region of the nephron is modified to carry out particular tasks. The most important tasks are **filtration, reabsorption,** and **secretion** (see Box). However, the last two processes depend on the first, and homeostasis of the blood can be maintained only if sufficient filtrate is formed. Without filtrate the tubules have nothing to reabsorb and no urine is formed.

The nephrons process approximately 180 liters of filtrate a day and normally can reabsorb all the filtrate's essential constituents because they have a considerable reserve reabsorption capacity. However, there is an upper limit to the quantity of each solute that can be actively reabsorbed. This upper limit is called the **transport maximum,** and it is expressed as the maximum amount that can be completely reabsorbed in 1 minute. For example, the transport maximum of glucose is 225 mg a minute. This is normally reached when the blood glucose rises to 180 mg/dl. At higher concentrations, glucose begins to be lost in the urine.

Filtration is a function of Bowman's capsule, whereas reabsorption and secretion are functions of the tubules and collecting ducts.

BOWMAN'S CAPSULE

Bowman's capsule is shaped like a cup, in which the glomerular capillaries fit snugly (Figure 1-7). The endothelial cells of the glomerular capillaries have large pseudofenestrae (pores), and there are gaps (slits) between the podocytes that form the inner wall of Bowman's capsule (Figure 1-8). These pores and the connective tissue between them form a semipermeable membrane that allows water and small molecules to pass through easily but prevents plasma pro-

REGIONS OF THE NEPHRON AND THEIR PRIMARY FUNCTIONS

Bowman's capsule

Filtration: Ultrafiltrate of plasma enters Bowman's capsule and flows into the proximal convoluted tubule

Proximal convoluted tubule

Obligatory reabsorption (approximately 66% of the glomerular filtrate): Sodium, potassium, chloride, bicarbonate, and other electrolytes; glucose; amino acids; water; and urea
Secretion: Hydrogen ions and some unwanted substances (drugs and toxins)

Loop of Henle

Reabsorption (approximately 25% of the glomerular filtrate): Chloride, sodium, and calcium ions; water; and urea

Distal convoluted tubule

Facilitatory reabsorption (approximately 9% of the glomerular filtrate): Sodium, chloride, bicarbonate, water, and urea
Secretion: Hydrogen, potassium, and ammonia

Collecting duct

Facilitatory reabsorption: Water and urea

Note: **Obligatory reabsorption** depends on the maximum capacity of the tubular cells. It is not thought to be affected by hormonal mechanisms. **Facilitatory reabsorption** depends on hormones such as antidiuretic hormone, aldosterone, and atrial natriuretic peptide. **Urea** is absorbed passively wherever its concentration in the lumen increases as water leaves the tubule.

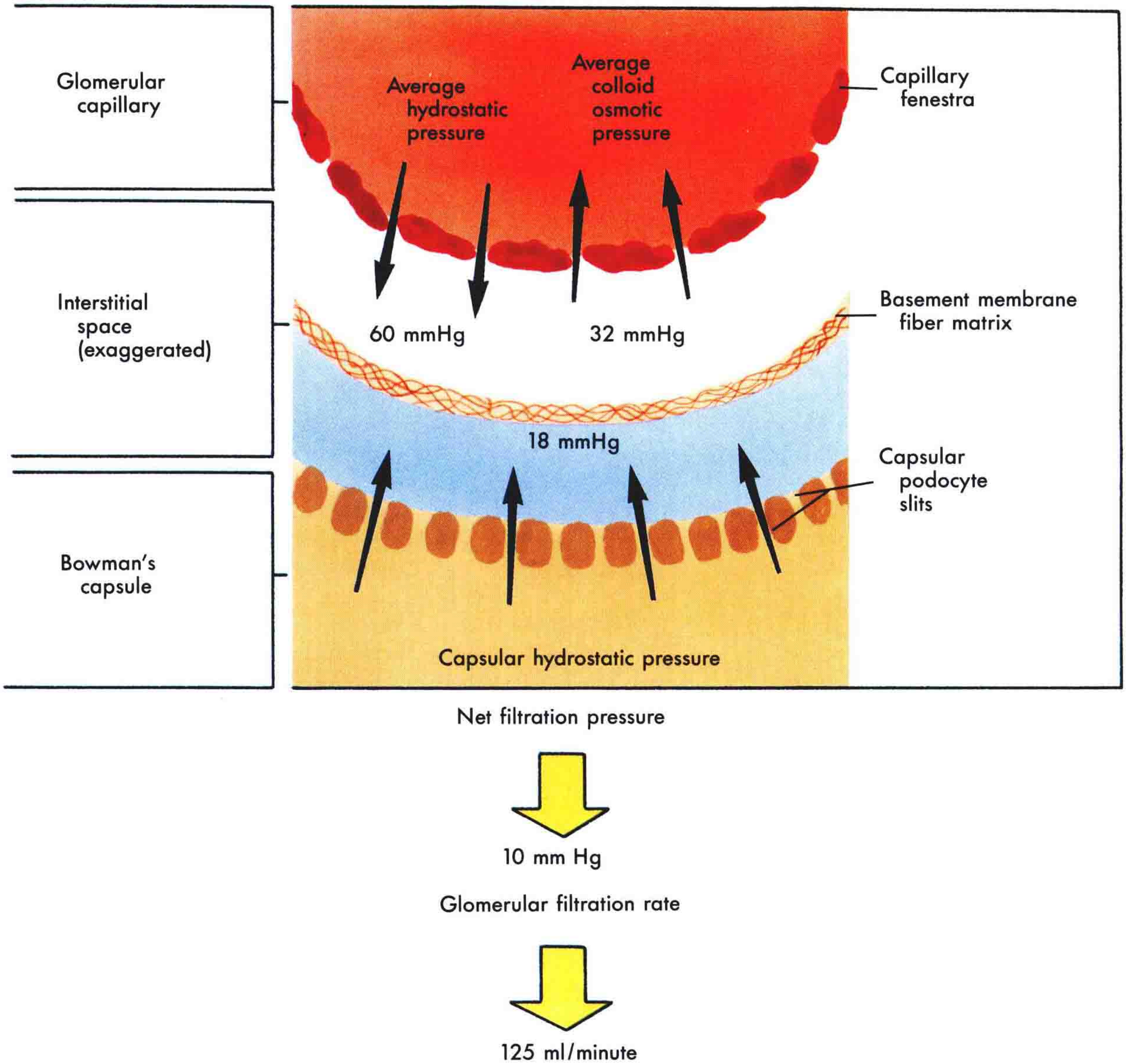

FIGURE 1-8
The three layers of the glomerular filtration membrane, separated to show the pores and the pressures affecting net filtration pressure and thus the glomerular filtration rate.

teins and erythrocytes from doing so. (In some diseases, antigen-antibody complexes are produced that can pass through the pseudofenestrae but not through the capsular slits. These complexes cause an inflammatory reaction that damages the glomerular membrane and allows protein and sometimes even red blood cells to be lost in the urine. If red blood cells are lost, they hemolyze as they pass through the tubule, and free hemoglobin gives the urine a dark color.)

Approximately 20% of the plasma passing through the glomeruli filters into Bowman's capsule. This is equal to a **glomerular filtration rate** (GFR) of approximately 125 ml per minute (180 liters each day). The volume of filtrate entering Bowman's capsule depends on **net filtration pressure,** which is the difference between the outward push of the hydrostatic pressure and the inward attraction of the colloid osmotic pressure of the blood in the glomerular capillaries.

Hydrostatic blood pressure (capillary blood pressure) pushes against the wall and forces filtrate out of the glomerulus into Bowman's capsule; consequently, the glomerular filtration rate is very dependent on blood pressure. In individuals at rest, hydrostatic pressure in the glomerular capillaries is less than 60 mm Hg, compared with less than 35 mm Hg in other capillaries. Fluid already in the nephron opposes the entry of the filtrate with a hydrostatic pressure of approximately 18 mm Hg. Blood pressure in the afferent arteriole that supplies the glomerulus is so important that whenever pressure falls, pressure receptors in the afferent arteriole activate the renin-angiotensin hormone system of the juxtaglomerular apparatus, which functions to return afferent pressure to its optimum level. Nevertheless, vasoconstriction of the afferent arteriole can reduce net filtration pressure to 0 mm Hg, and activation of the sympathetic nervous system can completely inhibit urine production. This is normal during moderate exercise but can be serious if an individual is under prolonged stress or has a hemorrhage, trauma, or surgery. Therefore it is extremely important to monitor urine production after trauma and surgery, because failure to produce urine indicates that renal function has not returned to normal.

The **colloid osmotic pressure** of blood is approximately 28 mm Hg as it enters the glomerular capillaries. However, if 20% of the plasma filters into Bowman's capsule, the colloid osmotic pressure rises to approximately 36 mm Hg by the time the filtrate leaves in the efferent arteriole. Because colloid osmotic pressure opposes the formation of glomerular filtrate, conditions that reduce it (i.e., by reducing blood albumin concentration) tend to increase the quantity of fluid filtering into the tubule. Blood albumin concentration is kept constant by the

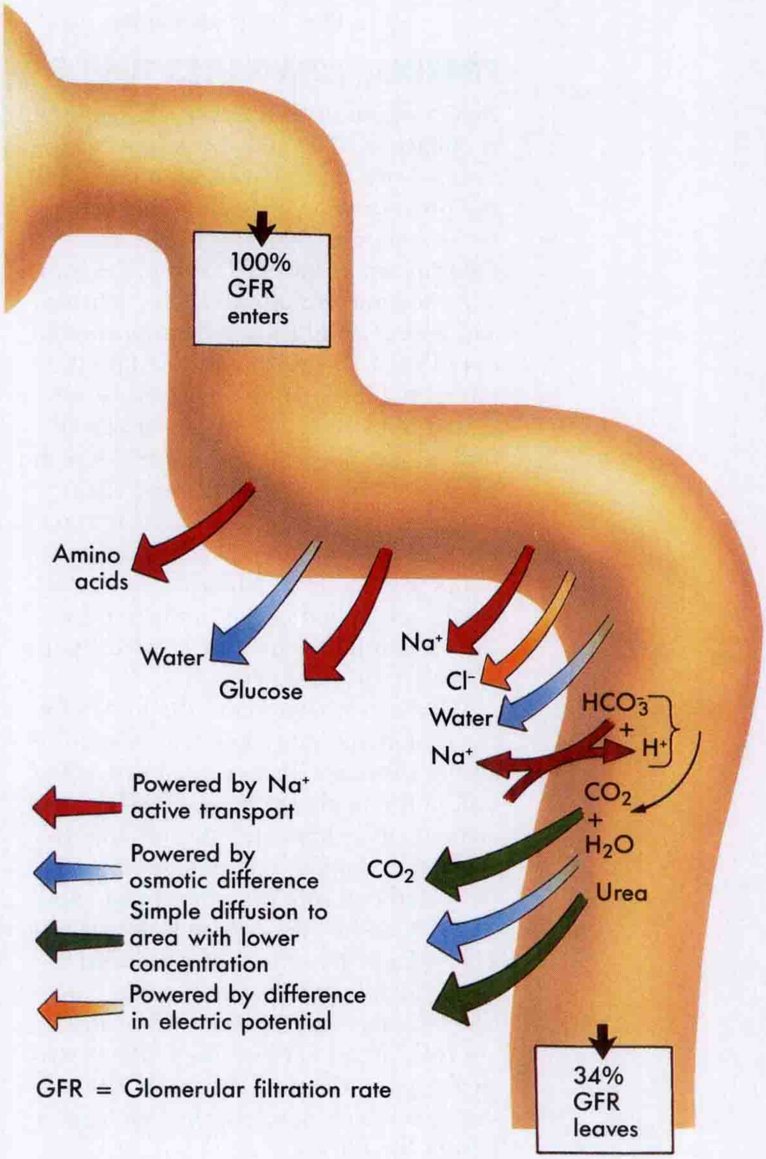

FIGURE 1-9
Active transport in the proximal convoluted tubule.