CHAPTER 1
Functional Anatomy of the Kidney

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A. Structural Organization of the Kidney

The kidney maintains the homeostasis of body fluids. This is accomplished by a complex process that involves, first, filtration of huge amounts of fluid and solutes from the blood across the wall of specialized capillaries of the glomerulus and, second, transepithelial transport of solutes and water along the tubular system connected to the glomerulus. In the tubular system solutes and water are reabsorbed into the systemic circulation and/or secreted into the tubular fluid. The waste products are excreted in a small fraction of the filtered fluid volume, generally in less than 1%, as the “final urine.” In addition, the kidney is an endocrine organ, producing hormones acting at sites outside as well as within the kidney.

I. Microanatomy of the Kidney

1. Nephron

The smallest microanatomical units of the kidney are the nephrons. The nephron consists of (a) the renal corpuscle containing the glomerulus and (b) the tubule that originates from the renal corpuscle. The nephrons are drained by a collecting system that finally delivers the urine into the renal pelvis. Microanatomically the nephron is subdivided into the proximal and distal convoluted parts, connected by a straight portion that is folded into a loop, the loop of Henle. Histologically, the nephron consist of a series of tubular segments, each with structurally and functionally characteristic cell types (Fig. 1).

A single nephron, together with its collecting system, is not sufficient to either concentrate or dilute the primary filtrate. This is the result of the specific juxtaposition of several thousands of nephrons working in parallel, and of their histotopographical relationships to the vascular system. The relationship of tubular segments with each other and with the intrarenal vasculature establishes the characteristic form and architecture of mammalian kidneys.

R. F. Greger et al. (eds.), Diuretics
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Fig. 1. Schematic representation of the segmentation of the tubular system in a superficial and deep nephron: 1, glomerulus within the renal corpuscle; 2,3, convoluted and straight part of the proximal tubule; 4,5, intermediate tubule; 6, thick ascending limb (TAL) of Henle’s loop; 8, distal convoluted tubule (DCT); 9, connecting tubule (CNT); 10, cortical; 11, outer medullary; 12, inner medullary collecting duct. (From KRIZ and BANKIR 1988, with permission)

Fig. 2A,B. Organization of the kidney and the renal vasculature. A Longitudinal section through a unipapillary kidney (rat); C, cortex; OS, outer stripe; IS, inner stripe; IM, inner medulla; P, papilla, belonging to the IM; U, ureter leaving the kidney at the hilum; the borders between the zones are indicated by broken lines; arrowheads, arcuate vessels, running along the corticomedullary border; small arrows, vascular bundles within the inner stripe; long arrow, cavity of the renal pelvis that is embedded in the connective tissue of the renal sinus; bar ≈1mm. B Schematic representation of the intrarenal vasculature (not drawn to scale; modified from KRIZ and BANKIR 1988, with permission); abbreviations as in A; within the cortex the medullary rays (MR) are delineated from the cortical labyrinth (CL) by dashed lines; 1/1a, interlobar artery and vein; 2/2a, arcuate artery and vein; 3/3a, cortical radial artery and vein; 4, stellate vein; 5, afferent arteriole; 6, efferent arteriole; 7a,b,c, superficial, midcortical and juxtamedullary glomerulus; 8,8a, juxtamedullary efferent arteriole, descending vasa recta; 9/9a, ascending vasa recta (within a vascular bundle and independent from a bundle, respectively); the dotted lines represent the capillary plexus, interposed between the arterial and venous vessels; arrows and arrowheads, direction of the blood flow (B adapted from KRIZ and BANKIR, with permission)