

# Introduction

## Part 1

### Chapters

- 1 The kidney: structural overview 2
- 2 The kidney: functional overview 4
- 3 Development of the renal system 6
- 4 Clinical features of kidney disease 8
- 5 The kidney: laboratory investigations and diagnostic imaging 10

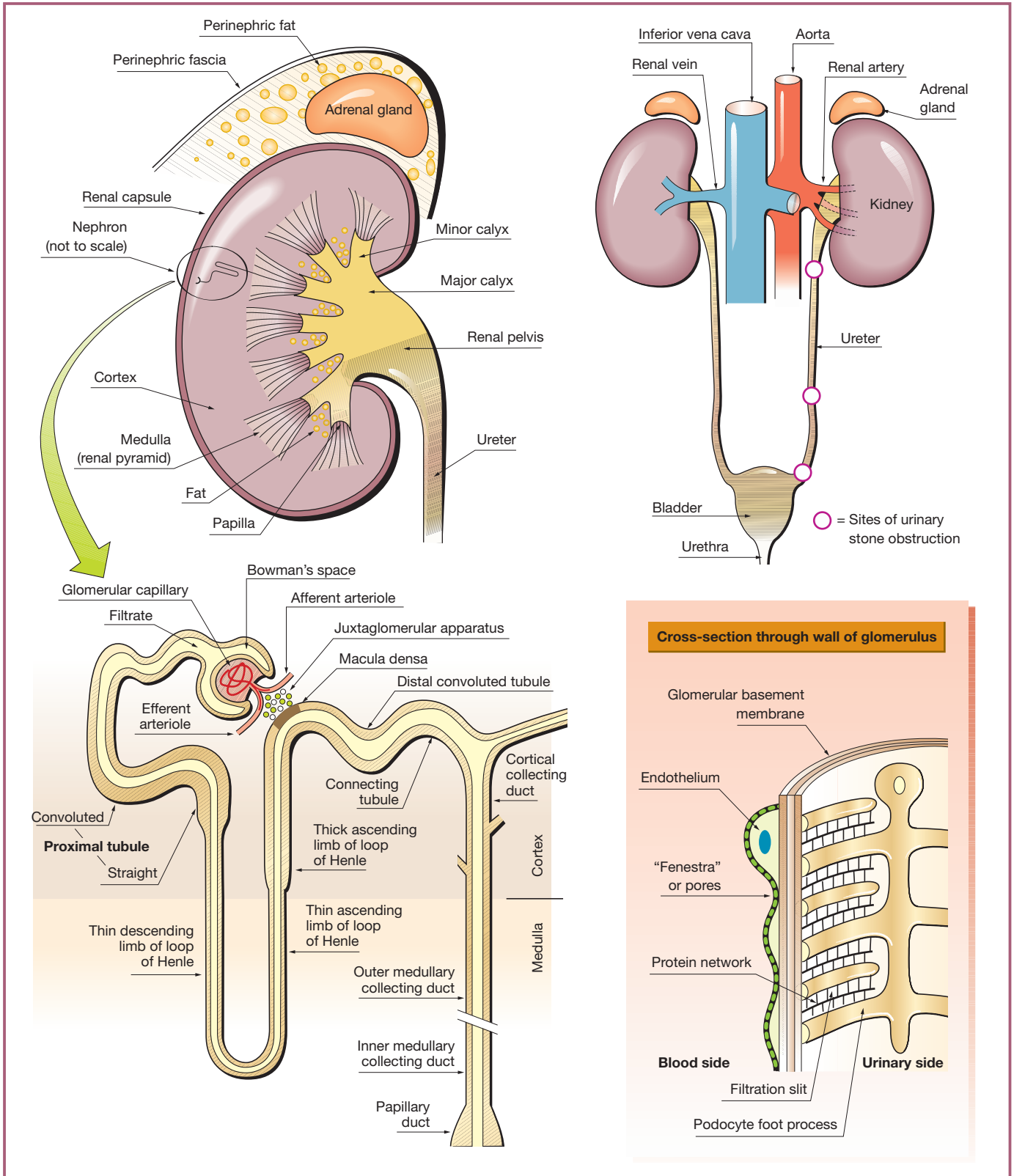


Don't forget to visit the companion website for this book  
[www.ataglanceseries.com/renalsystem](http://www.ataglanceseries.com/renalsystem)

COPYRIGHTED MATERIAL

# 1

## The kidney: structural overview



## Gross anatomy

### The kidney

The kidneys lie behind the peritoneum at the back of the abdominal cavity, extending from the twelfth thoracic vertebra (T12) to the third lumbar vertebra (L3). The right kidney is lower than the left because of the presence of the liver. During inspiration, both kidneys are pushed down as the diaphragm contracts. Each kidney is covered by a fibrous capsule. This is further surrounded by perinephric fat and then by the perinephric (perirenal) fascia, which also enclose the adrenal gland. The renal cortex is the outer zone of the kidney and the renal medulla is the inner zone made up of the renal pyramids. The cortex contains all the glomeruli, and the medulla contains the loops of Henle, the vasa recta, and the final portions of the collecting ducts.

### Vessels and nerves

Blood vessels and the ureter connect with the kidney at the renal hilus. The renal artery arises from the aorta and usually divides into three branches. Two pass in front of the ureter and one goes behind it. Five or six small veins come together to form the renal vein, which leaves the kidney in front of the anterior branch of the renal artery and enters the inferior vena cava. The position of the lymphatics and the renal sympathetic nerves is variable. The lymphatics drain to the lateral aortic lymph nodes. Sympathetic nerves supply the renal vasculature and juxtaglomerular apparatus, and to a lesser extent the rest of the nephron. Afferent fibers enter the spinal cord at T10, T11, and T12.

### The draining system for urine

Within the kidney, the pelvis of the ureter divides into two or three major calyces, each of which subdivides into two or three minor calyces. Each minor calyx contains a renal papilla, which is the apex of a medullary pyramid. The ureter passes out of the kidney behind the peritoneum on the psoas muscle and then enters the pelvis in front of the sacroiliac joint. It moves down the lateral pelvic wall toward the ischial spine and then turns forward and medially to enter the bladder. It passes through the bladder wall for 2 cm before opening into the bladder. Urine passes along the ureter by peristalsis. The ureter has three constrictions where kidney stones can become lodged (see Chapter 51). Afferent nerves from the ureter enter the spinal cord at T11, T12, L1, and L2. The bladder is innervated by S3, S4, and S5.

## Microanatomy

### The nephron

The nephron is the basic unit of the kidney. Each kidney has 400,000–800,000 nephrons, although this number falls with age.

A nephron consists of the glomerulus and the associated tubule that leads to the collecting duct. Urine is formed by filtration in the glomerulus; it is then modified in the tubules by the reabsorption and secretion of substances. Cortical nephrons occur throughout the renal cortex and have short loops of Henle; juxtamedullary nephrons begin near the corticomedullary junction and have long loops of Henle, which descend deep into the medulla and enable them to concentrate urine effectively. Cortical nephrons outnumber juxtamedullary nephrons by 7:1.

### Interstitial cells in the kidney

The cortex contains two types of interstitial cell: phagocytic and fibroblast-like cells. Erythropoietin is made in the fibroblast-like cells. Three types of medullary interstitial cells have been identified. One type contains lipid droplets, which may provide precursors for synthesis of prostaglandins in the kidneys.

## The glomerulus as a filtration barrier

### (see Chapter 7)

The glomerulus is a ball of capillaries surrounded by the Bowman's capsule, a hollow capsule of the tubular epithelium into which urine is filtered. The space into which the urine is filtered is known as Bowman's space. The glomerulus also contains mesangial cells, which provide a scaffold to support capillary loops and have contractile and phagocytic properties. Blood enters the glomerular capillaries from an afferent arteriole and leaves through an efferent arteriole, rather than a venule. Vasoconstriction of this efferent arteriole creates a high hydrostatic pressure in the glomerular capillary, forcing water, ions, and small molecules through the filtration barrier into Bowman's space. Whether a substance is filtered depends on both its molecular size and charge. The filtration barrier has three layers, all of which have a negative charge:

- 1 Endothelial cells.** The endothelial cells of the glomerular capillary wall are thin, with numerous 70-nm pores filled with negatively charged glycoprotein, mostly podocalyxin.
- 2 Glomerular basement membrane.** This specialized capillary basement membrane has three layers and contains negatively charged glycoproteins attached to a three-dimensional framework of collagen and other proteins.
- 3 Epithelial cells of Bowman's capsule.** The epithelial cells or podocytes have long projections from which foot processes arise and attach to the urinary side of the glomerular basement membrane. Foot processes from different podocytes interdigitate, leaving filtration slits of 25–65 nm between them. Across these slits, a protein network rich in nephrin protein forms "slit pores." The pores are the key selectivity barrier in the filtration process and prevent the passage of larger molecules such as albumin.