# Chapter 12
# Flow Through the Kidney

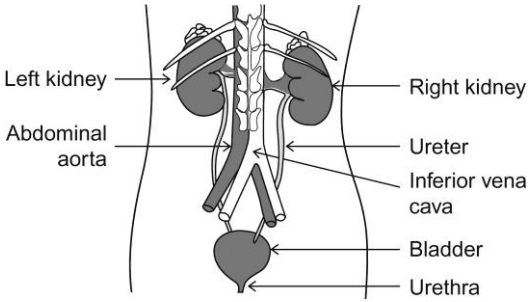


**Figure 12.1** Anatomical location (posterior view) of the kidneys, showing their location in relation to other structures in the abdomen. The kidneys are protected by the eleventh and twelfth ribs (both shown). Urine formed in the kidneys passes through the left and right ureter into the bladder. As the bladder fills, urine can be removed from the body via the urethra. *Adapted from Martini and Nath (2009)*.

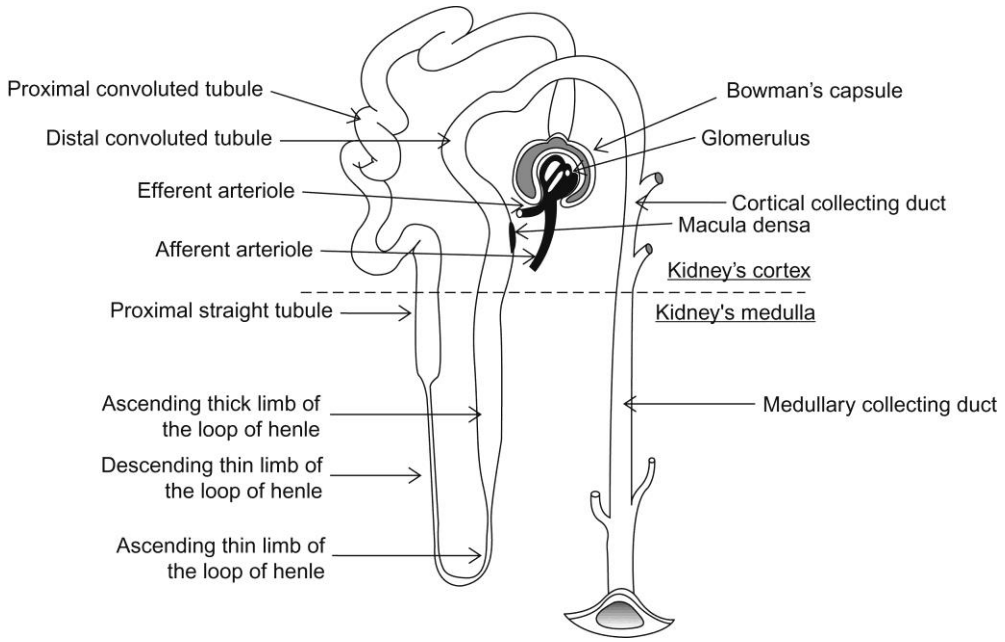


**Figure 12.2** Schematic of the functional unit of a kidney: the nephron. This figure illustrates the anatomical arrangement of the nephron. Notice that the macula densa is a grouping of cells and not a particular region of the kidney. Blood is filtered in the glomerulus and the filtrate passes through the nephron (proximal convoluted tubule, Loop of Henle, distal convoluted tubule, and collecting duct) to form urine. *Adapted from Martini and Nath (2009)*.

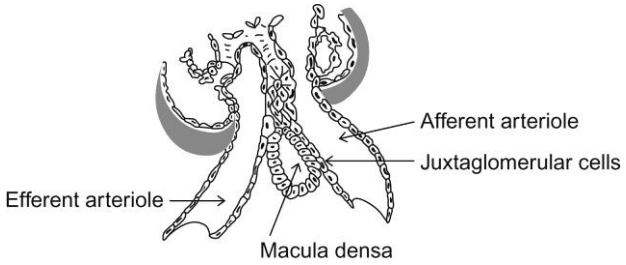


**Figure 12.3** Anatomical arrangement of the juxtaglomerular apparatus, which can monitor and regulate the glomerular filtration rate, through the production of renin. The thick ascending Loop of Henle passes between the afferent and efferent arterioles of the same nephron to form the juxtaglomerular apparatus. Depending on the concentration of sodium ions and chloride ions, the macula densa cells can either increase or decrease the production of renin. *Adapted from Martini and Nath (2009)*.

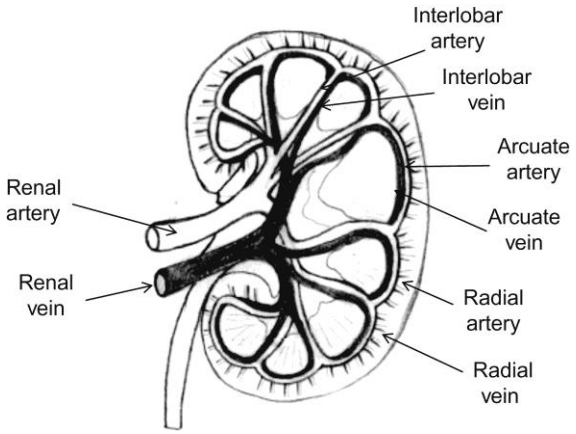


**Figure 12.4** Schematic of the renal vasculature, which comprises of one renal artery that bifurcates into the interlobar arteries. The interlobar arteries bend over the renal pyramids to form the arcuate arteries, which have the radial arteries coming off of them. The afferent arterioles to each glomerulus form from the radial arteries. The venous system follows a similar path as the arterial system.

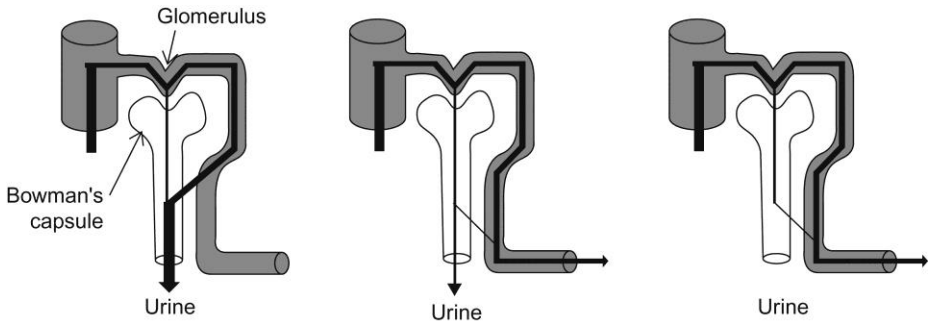


**Figure 12.5** Three possible scenarios for glomerular filtration, tubule secretion, and tubule reabsorption. In the first case, a small amount of substance is filtered and a large amount is secreted, so that there is a minimal concentration left in the peritubular capillaries. In the second scenario, some of the substance is filtered and reabsorbed. In the last case, all of the filtered substance is reabsorbed. Urea would fall under the first case (although it is not completely secreted), bicarbonate would be an example for the second case, and glucose would be an example for the third case. *Adapted from Widmaier et al. (2007)*.

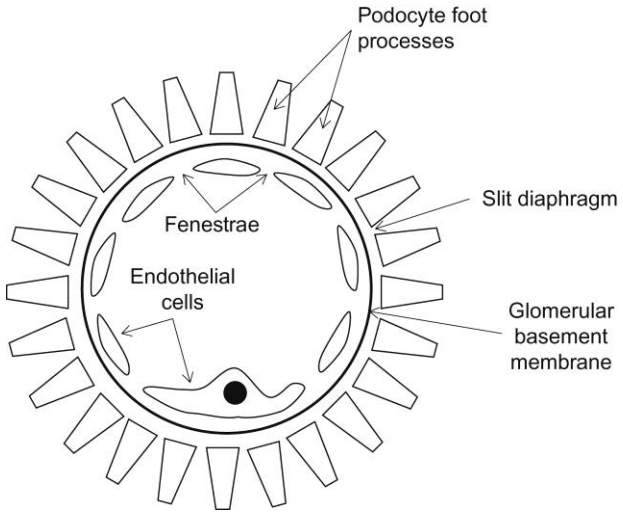


**Figure 12.6** Cross-section of a glomerular capillary surrounded by a basement membrane and foot processes of podocytes. The integrity of this barrier is critical to the processing of plasma and the production of the glomerular filtrate. For each particular molecule, a sieving coefficient can be defined that can be used to describe the filtration of that compound.

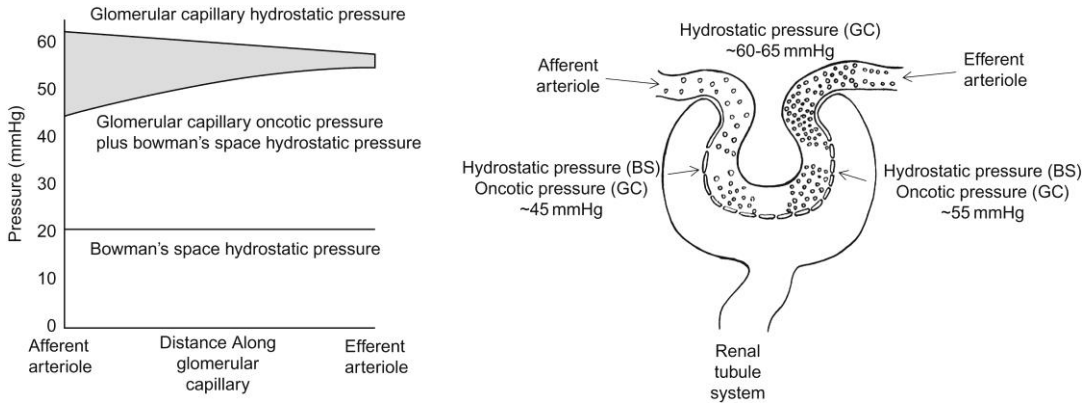


**Figure 12.7** Variation in the hydrostatic pressure of the glomerular capillaries and Bowman's Space and the glomerular capillary oncotic pressure as a function of distance along the glomerular capillary. There is a subtle drop in glomerular capillary hydrostatic pressure and an increase in the glomerular capillary oncotic pressure along the length of the glomerular capillaries. The oncotic pressure of the glomerular capillaries increases due to a net movement of protein-free materials out of the glomerular capillaries into the nephron tubule system. The hydrostatic pressure of Bowman's space (BS) is relatively constant over this length. Notice that the net filtration (the gray-shaded region) always favors movement of materials out of the glomerular capillaries. This is in contrast to "normal"•systemic capillaries, where materials move back into the capillary along the venous end. Note that this variation is a function of distance along the glomerular capillary (GC).

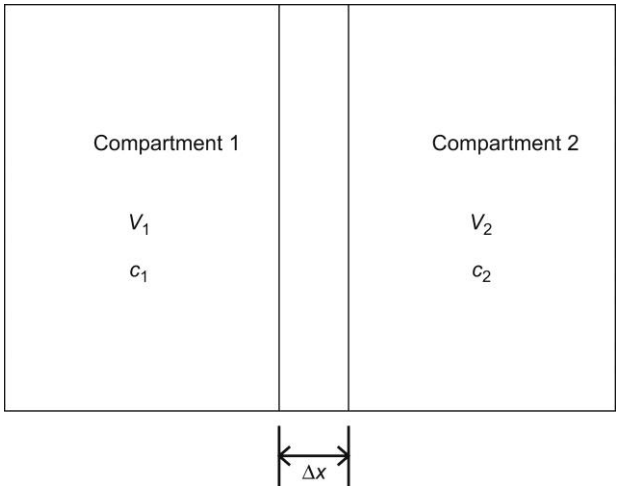


**Figure 12.8** Two-compartment model, separated by a semipermeable membrane of thickness $\Delta x$. This type of model can be used to analyze the solute transport through the nephron. To increase the complexity of the model, multiple compartments can be included separated by different semipermeable membranes.

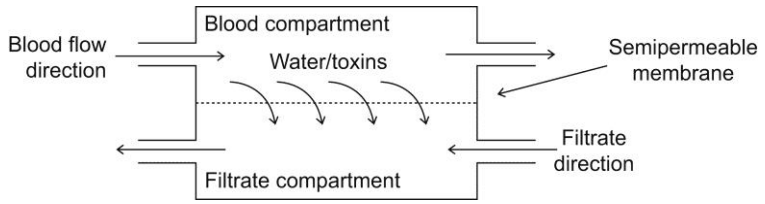


**Figure 12.9** Typical arrangement of a dialyzer to remove toxins from blood. A dialyzer would contain a semipermeable membrane that would be able to filter toxins from the blood and would leave all proteins, cells, and other necessary organic molecules within the blood. A countercurrent flow is used to maintain a concentration gradient along the entire membrane.

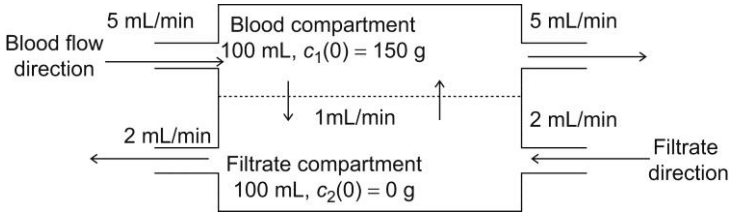


**Figure 12.10** Flow through an extracorporeal device for the in-text example problem.

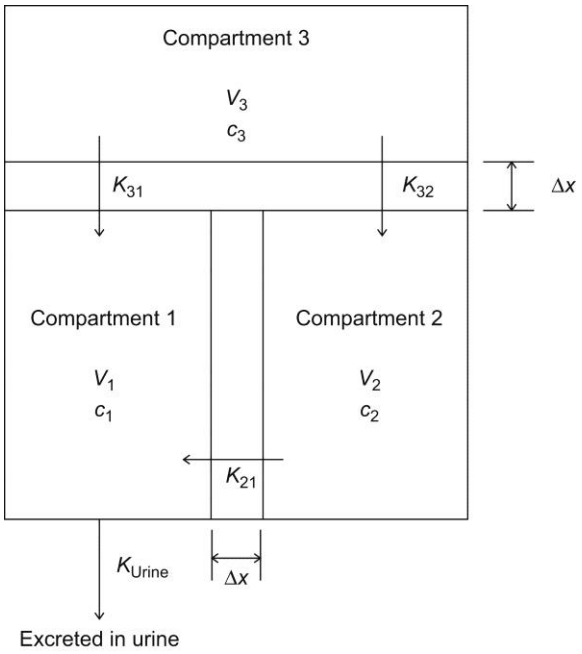


**Figure 12.11** Three-compartment model for Homework Problem 12.10.

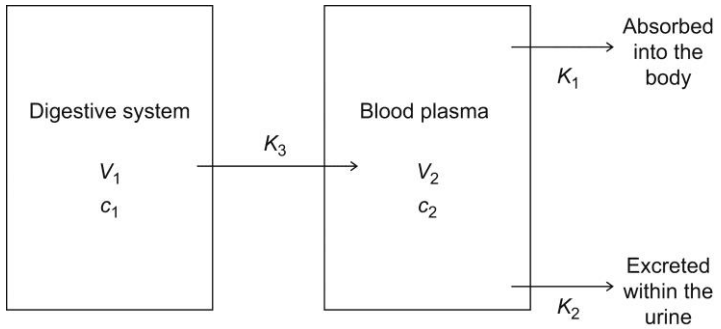


**Figure 12.12** Two-compartment model for Homework Problem 12.11.