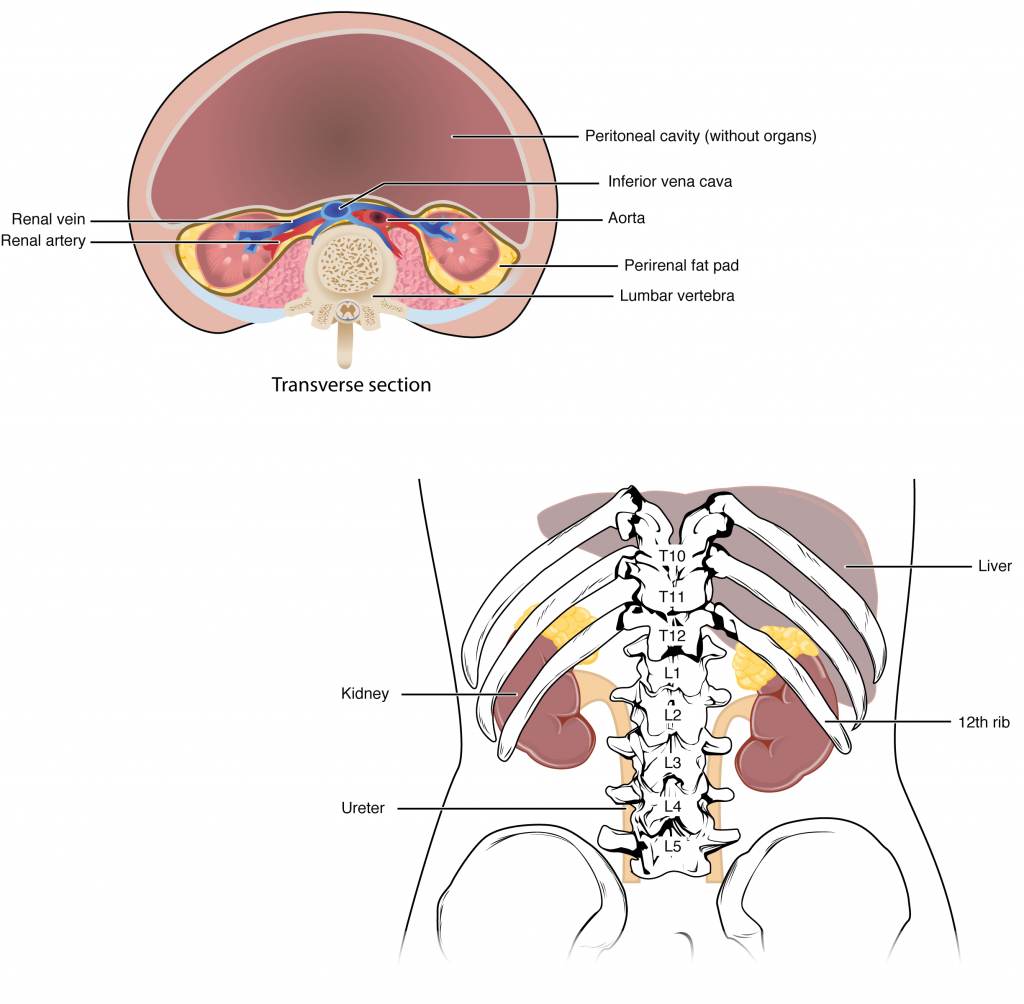
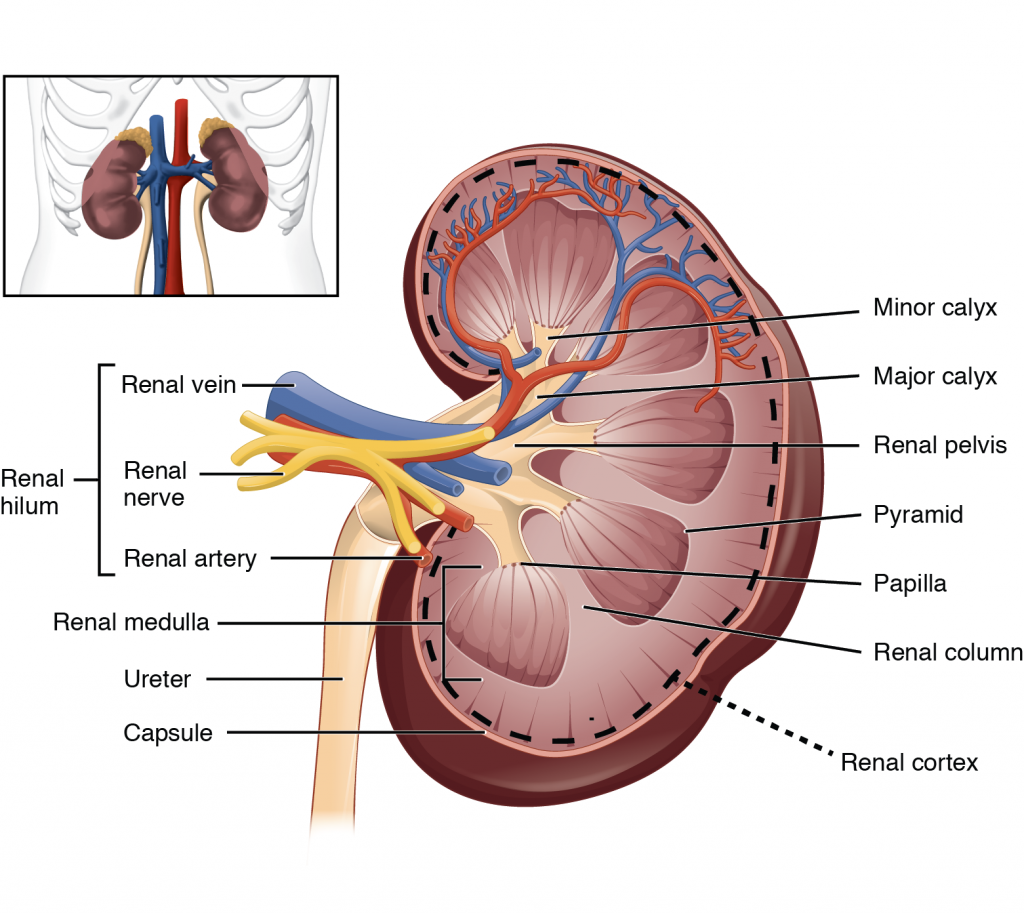
Urinary System



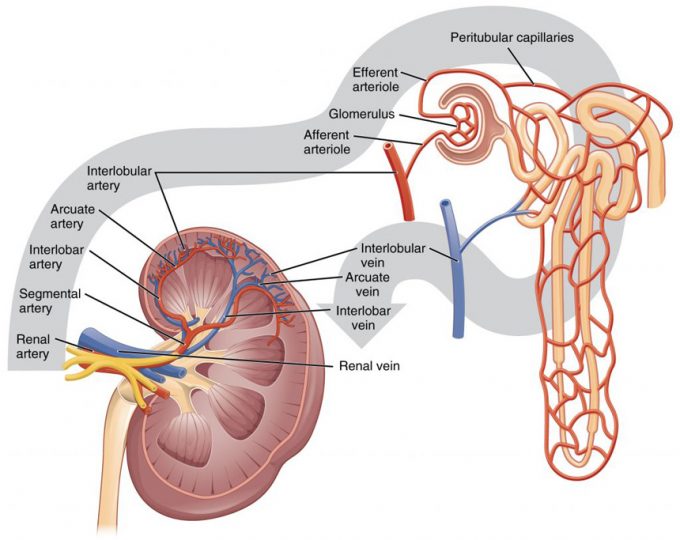
**Figure 1. Kidneys.** The kidneys are slightly protected by the ribs and are surrounded by fat for protection. On the superior aspect of each kidney is an adrenal gland.

Kidney Anatomy



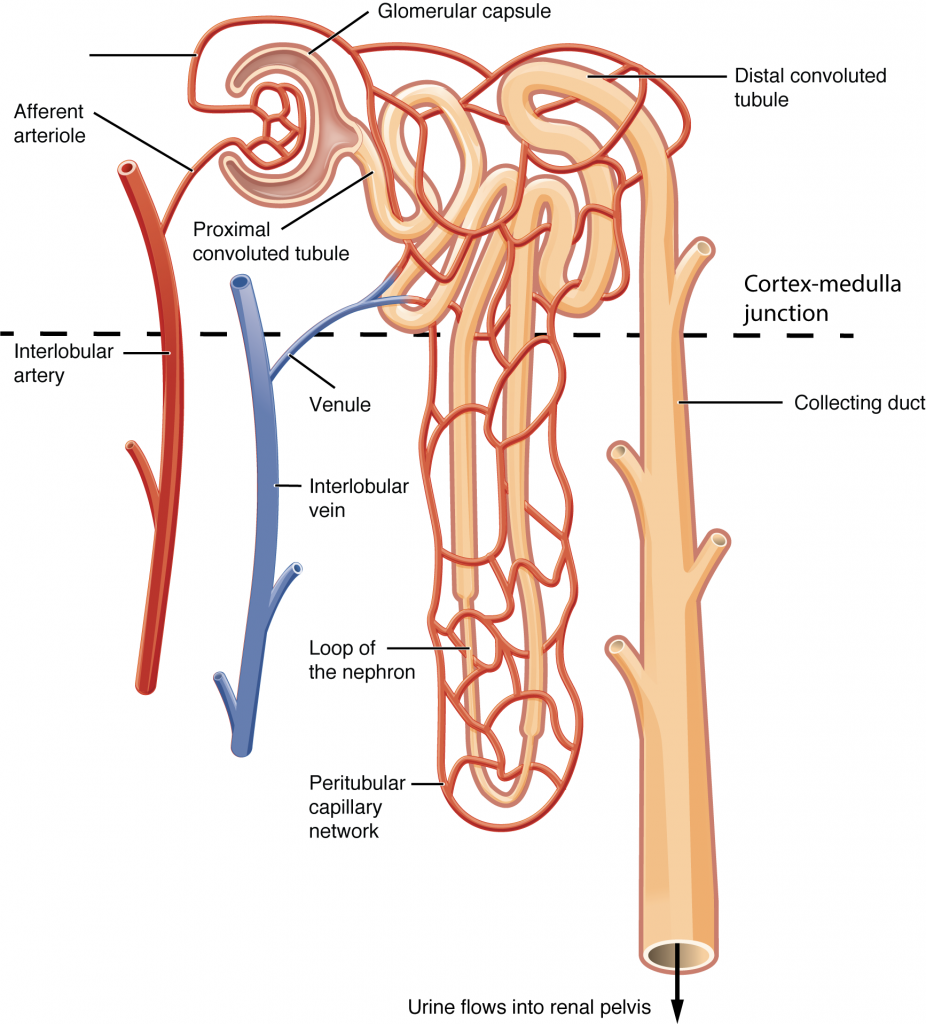
**Figure 2. Left Kidney.**

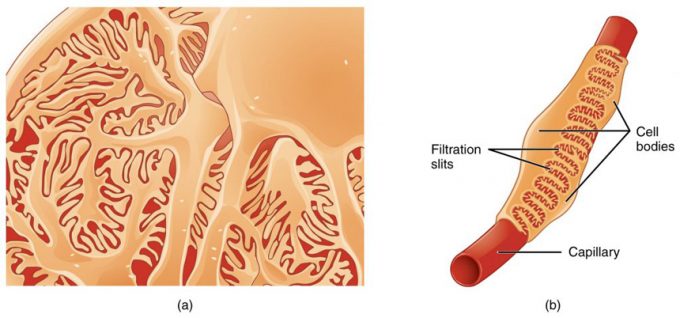
Blood Supply to Kidney



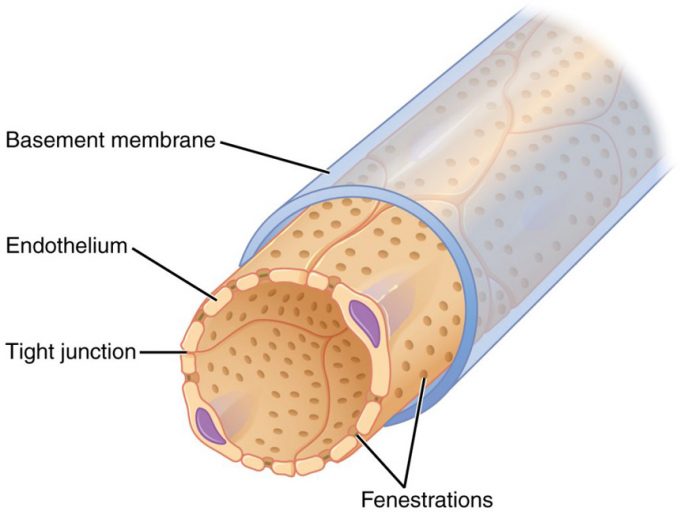
**Figure 3. Blood Flow in the Kidney.**

Nephrons

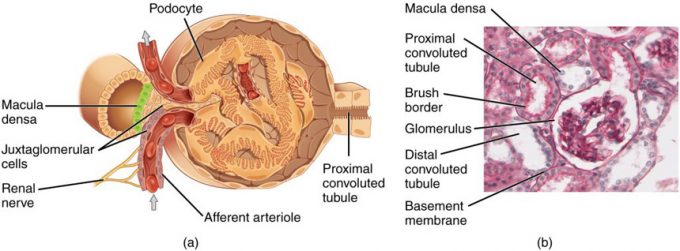




**Figure 1. Podocytes.** Podocytes interdigitate with structures called pedicels and filter substances into the glomerular capsule. In (a), the large cell body can be seen at the top right corner, with branches extending from the cell body. The smallest finger-like extensions are the pedicels.

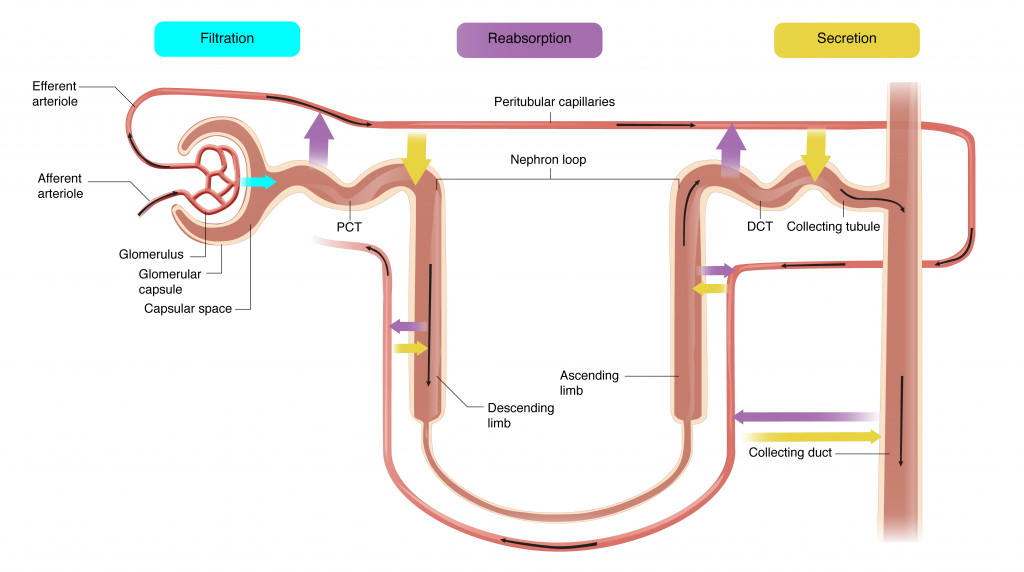


**Figure 2. Fenestrated Capillary.** Fenestrations allow many substances to leave the blood based primarily on size.



**Figure 3. Juxtaglomerular Apparatus and Glomerulus.** (a) The JGA allows specialized cells to monitor the composition of the fluid in the DCT and adjust the glomerular filtration rate. (b) This micrograph shows the glomerulus and surrounding structures. LM × 1540. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

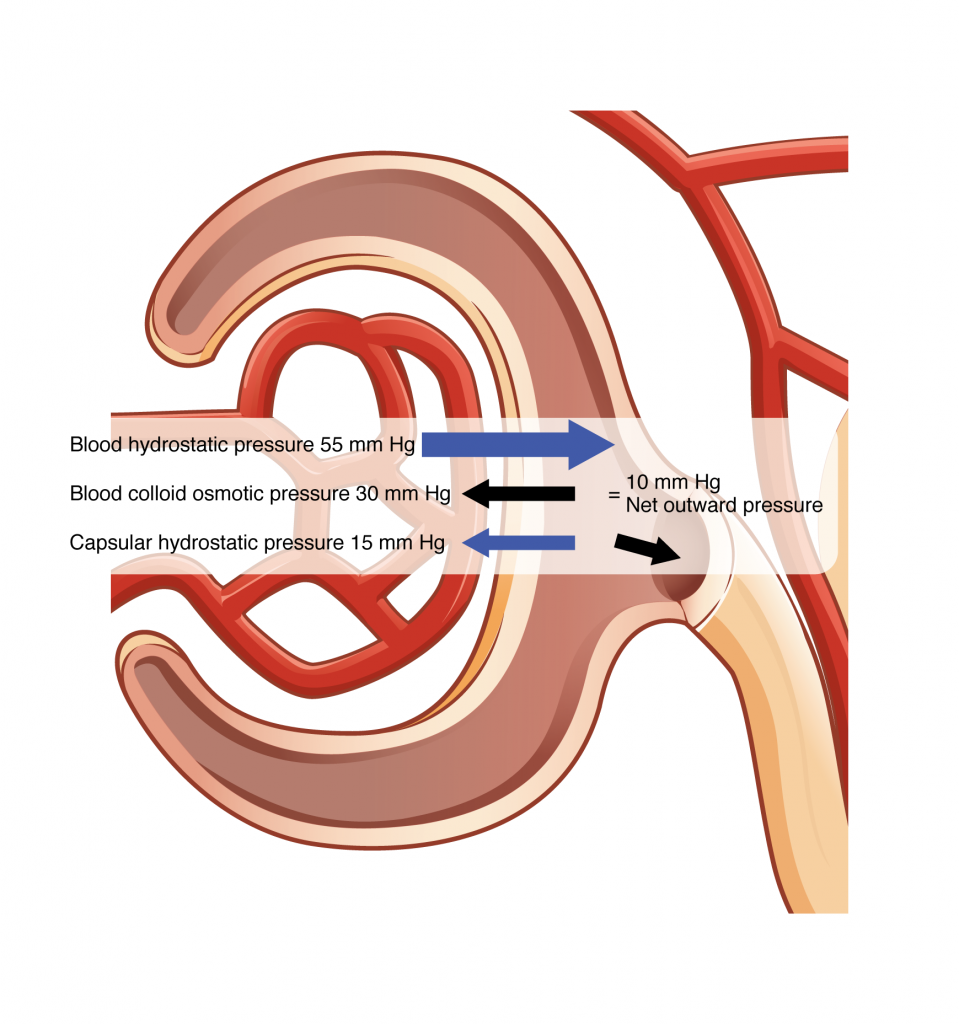
Urine Formation



**Figure 1. Urine formation**

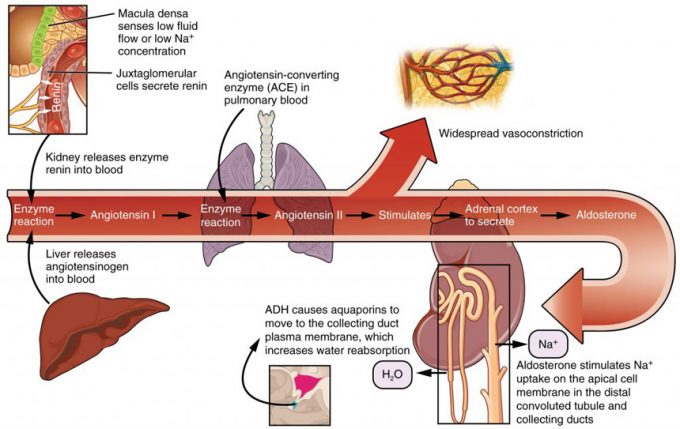
| **Substances Secreted or Reabsorbed in the Nephron and Their Locations (Table 5)** | | | | |
| --- | --- | --- | --- | --- |
| **Substance** | **PCT** | **Loop of Henle** | **DCT** | **Collecting ducts** |
| Glucose | Almost 100 percent reabsorbed; secondary active transport with Na+ |  |  |  |
| Oligopeptides, proteins, amino acids | Almost 100 percent reabsorbed; symport with Na+ |  |  |  |
| Vitamins | Reabsorbed |  |  |  |
| Lactate | Reabsorbed |  |  |  |
| Creatinine | Secreted |  |  |  |
| Urea | 50 percent reabsorbed by diffusion; also secreted | Secretion, diffusion in descending limb |  |  |
| Sodium | 65 percent actively reabsorbed | 25 percent reabsorbed in thick ascending limb; active transport | 5 percent reabsorbed; active | 5 percent reabsorbed, stimulated by aldosterone; active |
| Chloride | Reabsorbed, symport with Na+, diffusion | Reabsorbed in thin and thick ascending limb; diffusion in ascending limb | Reabsorbed; diffusion | Reabsorbed; symport |
| Water | 67 percent reabsorbed osmotically with solutes | 15 percent reabsorbed in descending limb; osmosis | 8 percent reabsorbed if ADH; osmosis | Variable amounts reabsorbed, controlled by ADH, osmosis |
| Bicarbonate | 80–90 percent symport reabsorption with Na+ | Reabsorbed, symport with Na+ and antiport with Cl–; in ascending limb |  |  |
| H+ | Secreted; diffusion |  |  |  |
| NH4+ | Secreted; diffusion |  |  |  |
| HCO3– | Reabsorbed; diffusion | Reabsorbed; diffusion in ascending limb | Reabsorbed; diffusion | Reabsorbed; antiport with Na+ |
| Some drugs | Secreted |  |  |  |
| Potassium | 65 percent reabsorbed; diffusion | 20 percent reabsorbed in thick ascending limb; symport | Secreted; active | Secretion controlled by aldosterone; active |
| Calcium | Reabsorbed; diffusion | Reabsorbed in thick ascending limb; diffusion |  |  |
| Magnesium | Reabsorbed; diffusion | Reabsorbed in thick ascending limb; diffusion | Reabsorbed |  |
| Phosphate | 85 percent reabsorbed, inhibited by parathyroid hormone, diffusion |  |  |  |

Glomerular Filtration



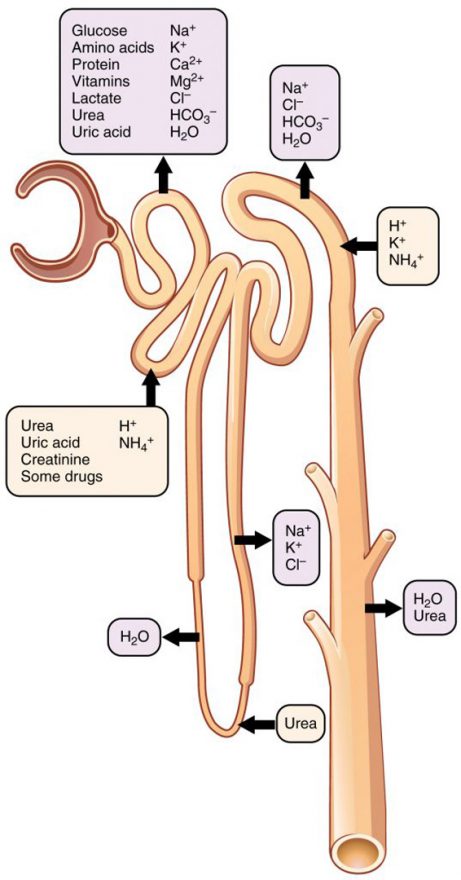
**Figure 1. Net Filtration Pressure.** The NFP is the sum of osmotic and hydrostatic pressures.

|  |
| --- |
|  |
| **Paracrine Mechanisms Controlling Glomerular Filtration Rate (Table 8)** | | | |
| **Change in GFR** | **NaCl Absorption** | **Role of ATP and adenosine/Role of NO** | **Effect on GFR** |
| Increased GFR | Tubular NaCl increases | ATP and adenosine increase, causing vasoconstriction | Vasoconstriction slows GFR |
| Decreased GFR | Tubular NaCl decreases | ATP and adenosine decrease, causing vasodilation | Vasodilation increases GFR |
|  |  |  |  |
|  |  |  |  |

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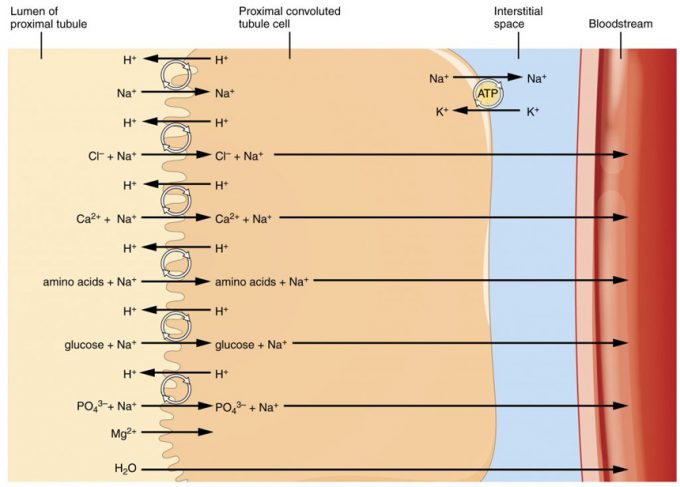
**Figure 4. Conversion of Angiotensin I to Angiotensin II.** The enzyme renin converts the pro-enzyme angiotensin I; the lung-derived enzyme ACE converts angiotensin I into active angiotensin II

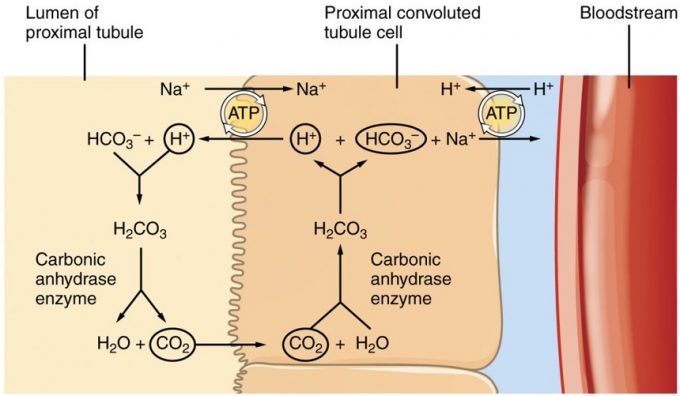
Physiology of Urine Formation



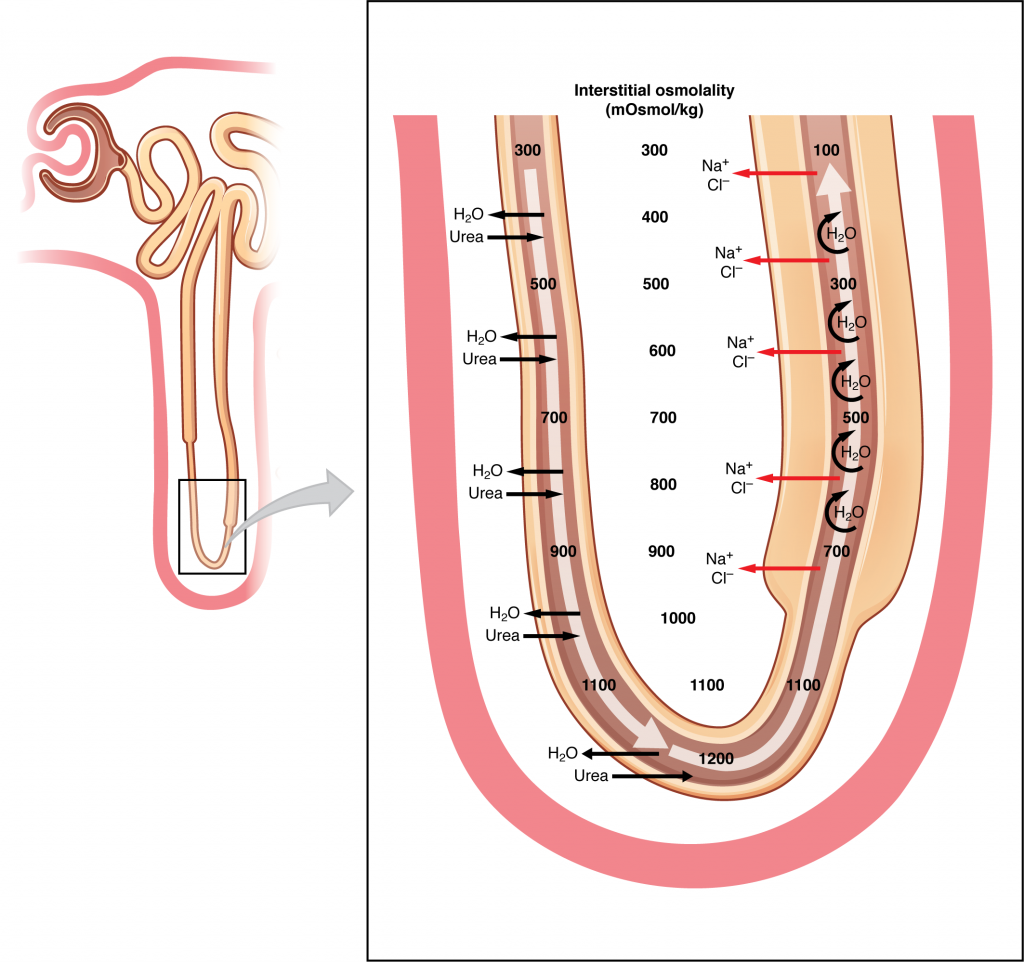
**Figure 1. Locations of Secretion and Reabsorption in the Nephron.**

PCT

 **Figure 2. Substances Reabsorbed and Secreted by the PCT.**

 **Figure 3. Reabsorption of Bicarbonate from the PCT.**

Loop of Henle



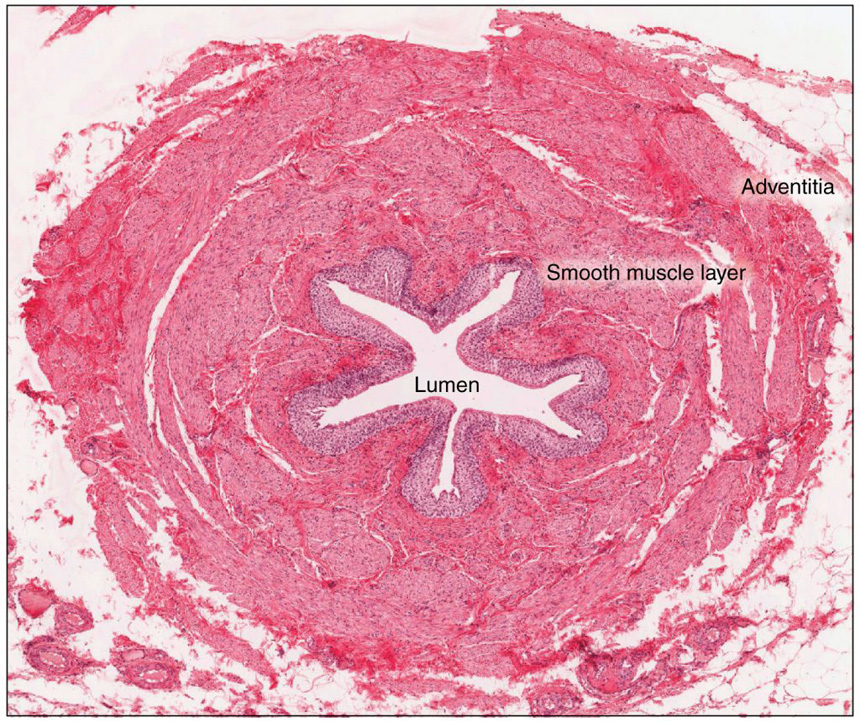
**Figure 4. Countercurrent Multiplier System.**

Regulation of Urine Concentration

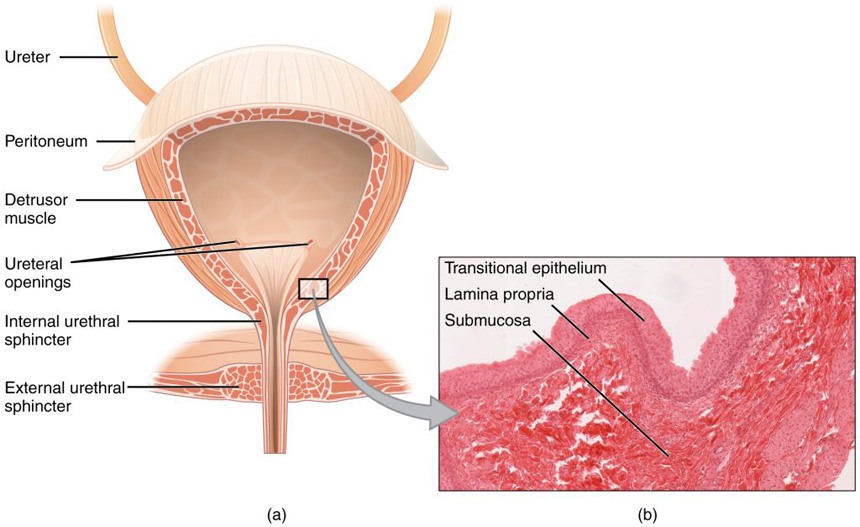
Urine

| **Normal Urine Characteristics (Table 1)** | |
| --- | --- |
| **Characteristic** | **Normal values** |
| Color | Pale yellow to deep amber |
| Odor | Odorless |
| Volume | 750–2000 mL/24 hour |
| pH | 4.5–8.0 |
| Specific gravity | 1.003–1.032 |
| Osmolarity | 40–1350 mOsmol/kg |
| Urobilinogen | 0.2–1.0 mg/100 mL |
| White blood cells | 0–2 HPF (per high-power field of microscope) |
| Leukocyte esterase | None |
| Protein | None or trace |
| Bilirubin | <0.3 mg/100 mL |
| Ketones | None |
| Nitrites | None |
| Blood | None |
| Glucose | None |

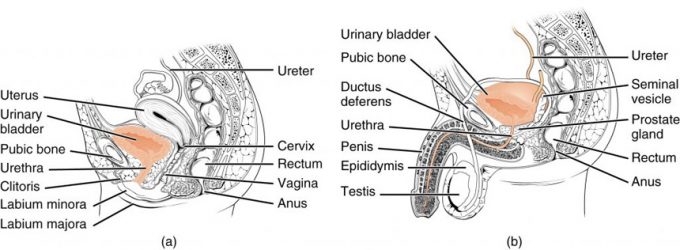
Urine Transport



**Figure 4. Ureter.**Peristaltic contractions help to move urine through the lumen with contributions from fluid pressure and gravity. LM × 128. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012)

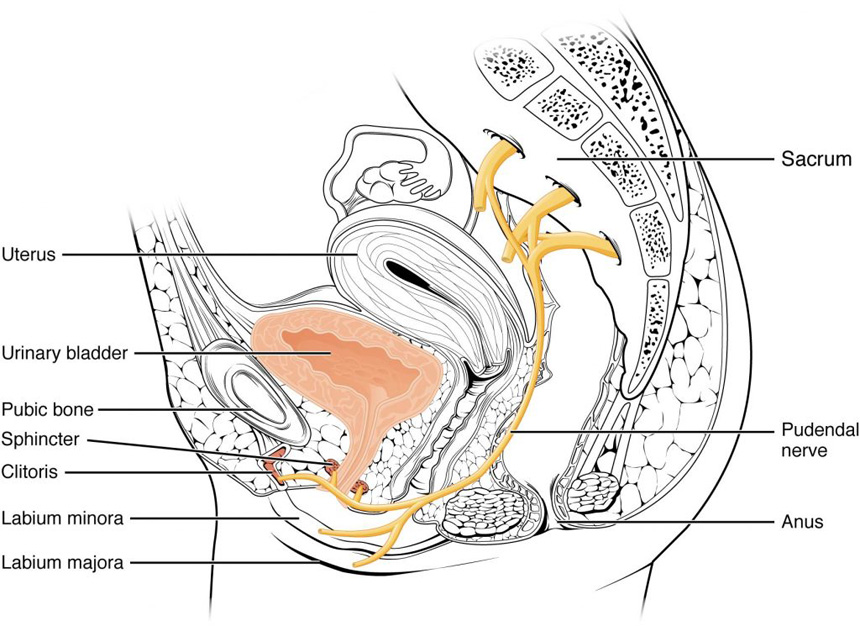


**Figure 2. Bladder.** (a) Anterior cross section of the bladder. (b) The detrusor muscle of the bladder (source: monkey tissue) LM × 448. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012)



**Figure 1. Female and Male Urethras.**The urethra transports urine from the bladder to the outside of the body. This image shows (a) a female urethra and (b) a male urethra.

Micturition



**Figure 3. Nerves Innervating the Urinary System.**