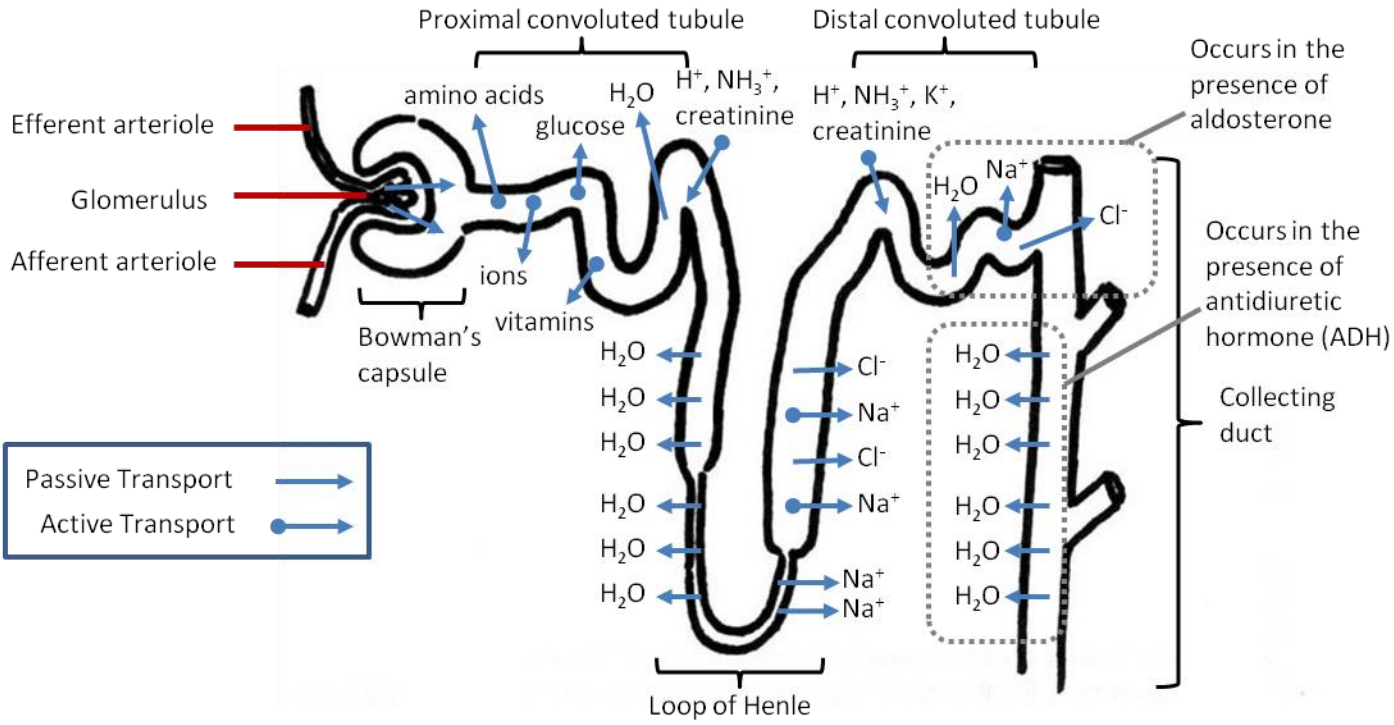
# Urinary System




**Steps in Urine Formation:**

1. *Filtration* – occurs at the renal corpuscle which includes the glomerulus and the Bowman's (glomerular) capsule
    - Filtration is dependent on blood pressure which forces particular substances from the glomerulus into the glomerular capsule
    - Substances are filtered based on size
        i. Small substances like water, electrolytes, amino acids, glucose, nitrogenous wastes (urea, uric acid, creatinine, ammonia) leave the glomerulus and enter into the nephron
        ii. Larger substances like protein and blood cells remain in the glomerulus and eventually moves into the efferent arteriole
2. *Reabsorption* – occurs throughout the remainder of the nephron, though primarily at the proximal convoluted tubule
    - Reabsorption depends on active and passive transport
    - Select substances are removed from the filtrate (in the nephron) and re-enter the peritubular capillaries
        i. These substances include glucose, amino acids, water, and electrolytes – nutrients that are useful to the body

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3. *Secretion* – occurs mainly in the proximal and distal convoluted tubule
    - Unwanted substances ($H^+$, $K^+$, certain drugs, etc.) that remain in the peritubular capillaries are actively or passively transported into the filtrate

Helpful animation: http://www.uic.edu/classes/bios/bios100/lectures/kidney_function.html

**Effect of Hormones:**

The presence of different hormones like antidiuretic hormone (ADH), aldosterone, calcitonin, atrial natriuretic hormone (ANH) and brain natriuretic hormone (BNH), in the blood can affect the amount of substances reabsorbed and secreted. These hormones mainly affect the distal convoluted tubules and the collecting duct.

Note: For additional info/practice see *Endocrine System Hormones Worksheet*

**Regulation of the Glomerular Filtration Rate (GFR):**

Glomerular filtration is necessary to remove waste products, regulate pH, and regulate blood volume/blood pressure. If glomerular filtration decreases, these functions would not occur and your body would not be able to maintain homeostasis. GFR can be regulated by the following:

1. Autoregulation of the afferent and efferent arteriole diameter
    a. Vasodilation of the afferent arteriole and vasoconstriction of the efferent arteriole increase GFR by increasing blood pressure
    b. Vasoconstriction of the afferent arteriole decreases GFR by decreasing the amount of blood entering into the glomerulus
2. Autonomic nervous system regulation
    a. Sympathetic nerves cause constriction of afferent arteriole, which decreases GFR by decreasing the amount of blood entering into the glomerulus
3. Hormone regulation
    a. Renin-angiotensin system responds to low blood pressure/blood volume and low GFR
        i. Renin is released by the juxtaglomerular complex
        ii. Renin converts angiotensinogen to angiotensin I
        iii. Angiotensin I is converted into angiotensin II by angiotensin-converting enzyme (ACE)
        iv. Angiotensin II causes constriction of arterioles, elevating blood pressure, and stimulates release of aldosterone and ADH, elevating blood volume
            - Aldosterone causes increase in $Na^+$ reabsorption and $K^+$ secretion – $Cl^-$ and water are reabsorbed passively
            - ADH causes the nephron to become permeable to water – water is reabsorbed
    b. Atrial Natriuretic Peptides (ANP) and Brain Natriuretic Peptides (BNP) respond to high blood volume
        i. ANP and BNP prevent renin production

**Practice Questions:**

1. What substances would you expect to find in the urine of a healthy human being? Circle all that apply.
    a. Urea
    b. Water
    c. Electrolytes (e.g. $Na^+$, $Ca^{2+}$, $K^+$, $H^+$)
    d. Protein
    e. Red blood cells
    f. White blood cells
    g. Uric acid
    h. Creatinine
    i. Glucose
    j. Amino acids
    k. Drugs
2. Alcohol inhibits ADH. How would drinking alcohol affect the amount of urine produced? Would you expect the urine to be concentrated or dilute?
3. If red blood cells or proteins were found in your urine, should you be concerned? Why or why not?
4. A person who has high blood pressure (hypertension) might be prescribed an ACE inhibitor. How can this help to lower blood pressure?
5. John decides to run a marathon on a hot sunny day but he forgets to bring a bottle of water. He sweats a lot and becomes dehydrated. How would John's kidneys react to retain enough water? Would the urine he produces be concentrated or dilute?
6. Calcitonin causes the nephrons to reabsorb less $Ca^{2+}$. If concentrations of calcitonin increase in the blood, would you expect more or less $Ca^{2+}$ in the urine? Would you expect more or less $Ca^{2+}$ in the blood?

**Answers:**

1. a, b, c, g, h, k
2. Without ADH, more water would leave the nephron and become part of urine. We would expect a larger volume of urine to be produced and the urine would be dilute because there is more water than normal.
3. If red blood cells or proteins were present in your urine, you should be concerned because a normally functioning kidney would not allow these large substances to enter into the glomerular capsule and end up in urine.
4. ACE inhibitor would prevent conversion of angiotensin I to angiotensin II. This would prevent aldosterone and ADH from being released. Because less $Na^+$ and water are reabsorbed, blood volume will be lowered. A lower blood volume would decrease blood pressure. As well, without angiotensin II, arterioles would not constrict and blood pressure would decrease.
5. John's lack of fluid intake would cause him to be dehydrated and have low blood volume and blood pressure. This would signal the renin-angiotensin system to start. The release of ADH and aldosterone would increase reabsorption of $Na^+$ and water to help maintain blood pressure. Because more water has been reabsorbed, John would expect a small volume of urine to be produced and it would be concentrated because there is little water present.
6. With increased calcitonin levels, more $Ca^{2+}$ should be found in urine and lower levels in the blood because less is reabsorbed.