Unit Seven

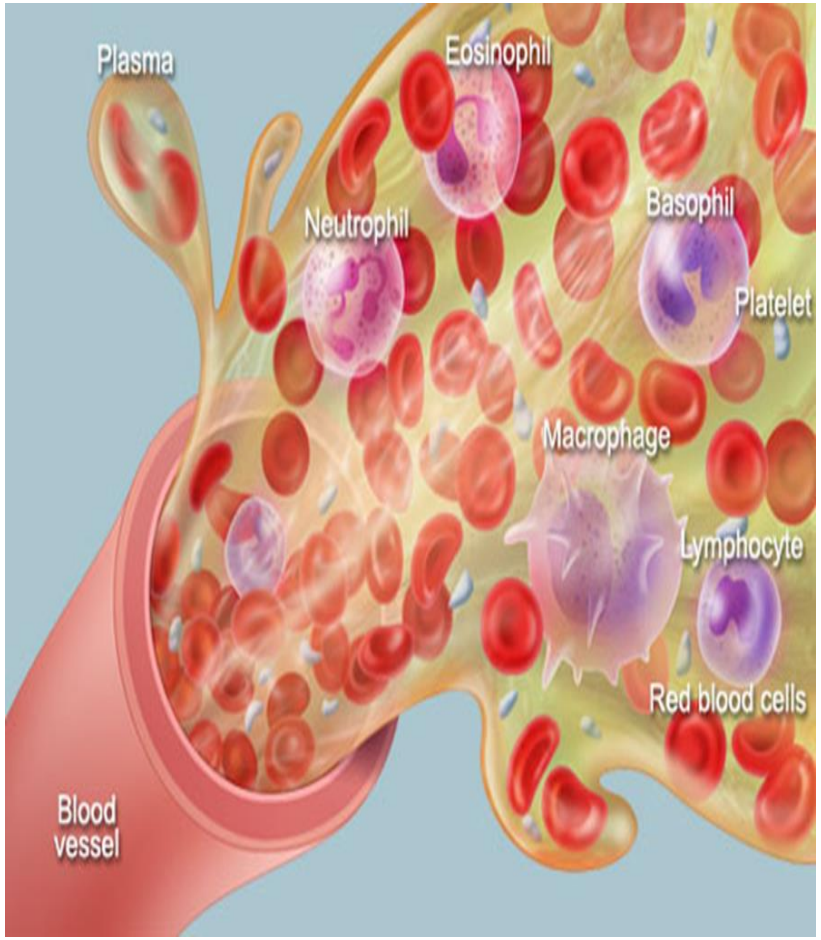
Chemistry of Blood & Urine

Assist. Lec. Sadoun Abbas Alsalimi
Department of Basic Sciences
College of Nursing
University of Basrah

Unit 7. Chemistry of Blood & Urine

Definition & Composition of Blood

Blood is a body fluid in humans and other animals that delivers necessary substances such as nutrients and oxygen to the cells and transports metabolic waste products away from those same cells. In human, it is composed of blood cells suspended in blood plasma. Plasma, which constitutes 55% of blood fluid, is mostly water (92% by volume), and contains proteins, glucose, mineral ions, hormones, carbon dioxide (plasma being the main medium for excretory product transportation), and blood cells themselves. The blood cells are mainly red blood cells (also called RBCs or erythrocytes), white blood cells (also called WBCs or leukocytes) and platelets (also called thrombocytes). The most abundant cells in human blood are RBC's. These contain hemoglobin, an iron-containing protein, which facilitates oxygen transport by reversibly binding to this respiratory gas and greatly increasing its solubility in blood. In contrast, carbon dioxide is mostly transported extracellularly as bicarbonate ion transported in plasma.



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Properties of Blood

Blood is bright red when its hemoglobin is oxygenated and dark red when it is deoxygenated. It is circulated around the body through blood vessels by the pumping action of the heart. In human, arterial blood carries oxygen from inhaled air to the tissues of the body, and venous blood carries carbon dioxide, a waste product of metabolism produced by cells, from the tissues to the lungs to be exhaled. In terms of anatomy and histology, blood is considered a specialized form of connective tissue, given its origin in the bones and the presence of potential molecular fibers in the form of fibrinogen. Blood accounts for 7% of the human body weight with an average density around 1060 kg/m3, very close to pure water's density of 1000 kg/m3. The average adult has a blood volume of roughly 5 liters. Blood pH is regulated to stay within the narrow range of 7.35 to 7.45, making it slightly basic.

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Functions of Blood

Blood performs many important functions within the body, including:

1- Supply of oxygen to tissues (bound to hemoglobin, which is carried in red cells).

2- Supply of nutrients such as glucose, amino acids, and fatty acids (dissolved in the blood or bound to plasma proteins (e.g., blood lipids)).

3- Removal of waste such as carbon dioxide, urea, and lactic acid.

4- Immunological functions, including circulation of white blood cells, and detection of foreign material by antibodies.

5- Coagulation, the response to a broken blood vessel, the conversion of blood from a liquid to a semisolid gel to stop bleeding.

6- Messenger functions, including the transport of hormones and the signaling of tissue damage.

7- Regulation of core body temperature.

8- Hydraulic functions.

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Definition & Function of Urine

Urine is a liquid by-product of metabolism in humans and in many other animals. Urine flows from the kidneys through the ureters to the urinary bladder. Urination results in urine being excreted from the body through the urethra. Cellular metabolism generates many by-products that are rich in nitrogen and must be cleared from the bloodstream, such as urea, uric acid, and creatinine. These by-products are expelled from the body during urination, which is the primary method for excreting water-soluble chemicals from the body. Urine plays an important role in the earth's nitrogen cycle. In balanced ecosystems, urine fertilizes the soil and thus helps plants to grow. Therefore, urine can be used as a fertilizer. Some animals use it to mark their territories. Historically, aged or fermented urine was also used for gunpowder production, household cleaning, tanning of leather and dyeing of textiles. The pH of urine varies from 5.5 to 7.5. If diet is rich in proteins, sulfuric and phosphoric acids are produced from amino acids, and the urine becomes acidic. If the diet is rich in vegetables, urine is alkaline because the organic acids (citric and tartaric) present in vegetables are converted to bicarbonate in the body.

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Characteristics of Urine

1- Volume: The average output of urine is about 1.5 liters per day. Urine volume may be increased in excess water intake, diuretic therapy, diabetes mellitus and in chronic renal diseases. Urine volume may be decreased in excess sweating, dehydration, edema of any etiology, kidney damage.

2- Appearance: It is clear and turns cloudy on standing due to precipitation of phosphates on refrigeration. Presence of pus causes cloudiness.

3- Odor: Normal urine has a faintly aromatic smell due to presence of volatile organic acids. Urine in diabetic ketoacidosis may have fruity odor due to acetone.

4- Color: Normal urine is straw colored (amber-yellow) due to the pigment, urochrome. Bilirubinuria (increased bilirubin level) in jaundice patients and increase vitamins B intake makes it yellow, Presence of blood makes it Smoky red, Hemoglobinuria makes it Brownish red, High levels of bilirubin and Rifampicin makes it Orange, Porphyria and Ingestion of red beet makes it red, Alkaptonuria and Formic acid poisoning makes it Black and Chyluria makes it milky.

5- Specific gravity: Normal specific gravity of urine is 1.015–1.025. Theoretical extremes are 1.003 to 1.032. The specific gravity will be decreased in excessive water intake, in chronic nephritis and in diabetes insipidus. It is increased in diabetes mellitus, in nephrosis and in excessive perspiration. The earliest manifestation of renal damage may be the inability to produce concentrated urine.