**(Slide 1) Lecture 5**

**Physiology of the blood system**

**(Slide 2)** Lecture plan:

1. Blood system concept.
2. Functions of the blood.
3. Cell Composition of blood.
4. Blood cells.

**(Slide 3) The blood system** is a combination of hematopoietic organs, peripheral blood, blood destruction organs and neurohumoral regulation apparatus. The term "blood system" was proposed by Georgy Fedorovich Lang in 1939.

Blood differs significantly from other tissues in a number of specific properties:

1. Blood is liquid, tissue moving through the vessels

2. Organs of production (red bone marrow, spleen, lymph nodes and organs of destruction − liver, spleen), as well as the apparatus of neurohumoral regulation are located separately from the liquid part of the blood itself circulating through the vessels.

Blood is a component of the internal environment of the body. Blood is often viewed as a kind of tissue in which interstitial fluid predominates over cell elements. In this context blood is regarded as a kind of a biological fluid. The ratio of cell elements to the liquid portion of blood is termed hematocrit. Cell elements account for 40-48 %, and the liquid portion accounts for 52-60% of the total blood volume. The liquid portion of blood is plasma.

Blood represents about 8% of total body weight and has an average volume of 5 liters in women and 5.5 liters in men. It consists of three types of specialized cellular elements, erythrocytes (red blood cells), leukocytes (white blood cells), and platelets (thrombocytes), suspended in the complex liquid plasma. Erythrocytes and leukocytes are both whole cells, whereas platelets are cell fragments.

**(Slide 4) Blood has three main functions:**

1. Transport.

2. Protective.

3. Homeostatic.

In turn, respiratory, nutritional, excretory, regulatory and thermoregulatory functions are also secreted in the transport function of blood.

**(Slide 5) Respiratory function of blood (Video).** Blood absorbs oxygen from air in the lungs. It transports the oxygen to cells throughout the body, and it removes waste carbon dioxide from the cells. In the lungs, the carbon dioxide moves from the blood to the air and is exhaled.

**(Slide 6) Video.** Observe how a red blood cell travels from the heart to the lungs.

**(Slide 7) Nutritional function of blood.** Digested nutrients are absorbed into the bloodstream through capillaries in the villi that line the small intestine. These nutrients include glucose, amino acids, vitamins, minerals, and fatty acids.

**(Slide 8) Excretory function of blood.** Blood transports waste substances to the organs that remove and process them for elimination. Blood flows into the kidneys through the renal arteries and out through the renal veins. The kidneys filter substances such as urea, uric acid, and creatinine out of the blood plasma and into the ureters. The liver also removes toxins from blood. During digestion, it cleans blood that has been enriched with vitamins before sending it back out to the rest of the body.

**(Slide 9) Regulatory function of blood.** The regulatory function of blood is the transfer of hormones produced by the endocrine glands and other biologically active substances, with the help of which the functions of individual tissue cells are regulated, as well as the removal of these substances and their metabolites after their physiological role has been fulfilled.

**(Slide 10) Thermoregulatory function of blood**. Blood absorbs and distributes heat throughout the body. It helps to maintain homeostasis through the release or conservation of warmth. Blood vessels expand and contract when they react to outside organisms, such as bacteria, and to internal hormone and chemical changes. These actions move blood and heat closer to or farther from the skin surface, where heat is lost.

**(Slide 11) Protective function of blood.** The protective function is carried out by substances that provide humoral protection of the body against infection and toxins entering the bloodstream, as well as by lymphocytes participating in the formation of antibodies. Cellular protection is carried out by leukocytes, which are carried by the blood stream to the site of infection, to the site of its penetration and, together with other tissue substances, provides the formation of a protective barrier. The blood stream removes and neutralizes the products of their destructuring formed in the event of tissue damage. The protective function of blood includes its ability to clot, form a blood clot and stop bleeding. Platelets are involved in this process. With a significant decrease in the number of platelets, slow blood coagulation is observed.

**(Slide 12) Homeostatic function of blood** − reaching the space of the internal environment of the body due to the movement of blood, washing all tissues with it, with the intercellular fluid of which its composition is balanced.

**(Slide 13) Characteristics of Blood.**

When you think about blood, the first characteristic that probably comes to mind is its color. Blood that has just taken up oxygen in the lungs is bright red, and blood that has released oxygen in the tissues is a darker red. This is because hemoglobin is a pigment that changes color, depending upon the degree of oxygen saturation.

Blood is viscous, with a viscosity approximately five times greater than water. Viscosity is a measure of a fluid’s thickness or resistance to flow, and is influenced by the presence of the plasma proteins and formed elements within the blood. The viscosity of blood has a dramatic impact on blood pressure and flow. Consider the difference in flow between water and honey. The more viscous honey would demonstrate a greater resistance to flow than the less viscous water. The same principle applies to blood.

The normal temperature of blood is slightly higher than normal body temperature − about 38 °C (or 100.4 °F), compared to 37 °C (or 98.6 °F) for an internal body temperature reading. Although, the surface of blood vessels is relatively smooth blood experiences friction and resistance as it flows. This produces heat, accounting for the slightly higher temperature of blood.

The pH of blood averages about 7.4; however, it can range from 7.35 to 7.45 in a healthy person. Blood is therefore somewhat more basic (alkaline) on a chemical scale than pure water, which has a pH of 7.0. Blood contains numerous buffers that help to regulate pH.

Blood constitutes approximately 8 percent of adult body weight. Adult males typically average about 5-6 liters of blood, and females average 4–5 liters.

**(Slide 14)** Composition of blood. Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid

2. Formed elements, which are made up of the blood cells and platelets

The formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape. All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells.

**(Slide 15)** Formed elements are:

1. Erythrocytes, also known as red blood cells (RBCs)

2. Leukocytes, also known as white blood cells (WBCs)

3. Platelets

In turn, all leukocytes are divided into neutrophils, eosinophils, basophils, monocytes and lymphocytes.

**(Slide 16)** The blood that runs through the veins, arteries, and capillaries is known as whole blood, a mixture of about 55 percent plasma and 45 percent blood cells. About 5 to 9 percent of your total body weight is blood. An average-sized man has about 6 liters of blood in his body, and an average-sized woman has about 5 liters. When a sample of blood is spun in a centrifuge, the cells and cell fragments are separated from the liquid intercellular matrix. Because the formed elements are heavier than the liquid matrix, they are packed in the bottom of the tube by the centrifugal force. The light yellow colored liquid on the top is the plasma, which accounts for about 55 percent of the blood volume and red blood cells is called the hematocrit, or packed cell volume (PCV). The white blood cells and platelets form a thin white layer, called the "buffy coat", between plasma and red blood cells.

**(Slide 17)** One such test examines hematocrit, which measures the percentage of RBCs (erythrocytes) in a blood sample. It is performed by spinning the blood sample in a specialized centrifuge, a process that causes the heavier elements suspended within the blood sample to separate from the lightweight, liquid plasma. Because the heaviest elements in blood are the erythrocytes, these settle at the bottom of the hematocrit tube. Located above the erythrocytes is a pale, thin layer composed of the remaining formed elements of blood. These are the WBCs (leukocytes) and the platelets (thrombocytes). This layer is referred to as the buffy coat, and it normally constitutes less than 1 percent of a blood sample. Above the buffy coat is the blood plasma, normally a pale, straw-colored fluid, which constitutes the remainder of the sample.

The volume of erythrocytes after centrifugation is also commonly referred to as packed cell volume. Typically, blood contains about 45 percent erythrocytes, however, samples can vary significantly from about 36–50 percent. Normal hematocrit values for females range from 37 to 47%, with a mean value of 41%; for males, hematocrit ranges from 42 to 52%, with a mean of 47%. The percentage of other formed elements, the WBCs and platelets, is extremely small so it is not normally considered with the hematocrit. Therefore, the mean plasma percentage is the percent of blood that is not erythrocytes: for females, approximately 59% (or 100 minus 41), and for males, approximately 53% (or 100 minus 47).

**(Slide 18)** Plasma is made up of 90% water, 7-8% soluble proteins (albumin maintains bloods osmotic integrity, others clot, etc), 1% carbon-dioxide, and 1% elements in transit. One percent of the plasma is salt, which helps with the pH of the blood. The largest group of solutes in plasma contains three important proteins to be discussed. There are: albumins, globulins, and clotting proteins.

**(Slide 19)** Albumins are the most common group of proteins in plasma and consist of nearly two-thirds of them (60-80%). They are produced in the liver. The main function of albumins is to maintain the osmotic balance between the blood and tissue fluids and is called colloid osmotic pressure. In addition, albumins assist in transport of different materials, such as vitamins and certain molecules and drugs (e.g. bilirubin, fatty acids, and penicillin).

Globulins are a diverse group of proteins, designated into three groups: gamma, alpha, and beta. Their main function is to transport various substances in the blood. Gamma globulins assist the body's immune system in defense against infections and illness.

Clotting proteins are mainly produced in the liver as well. There are at least 12 substances, known as "clotting factors" that participate in the clotting process. One important clotting protein that is part of this group is fibrinogen, one of the main components in the formation of blood clots. In response to tissue damage, fibrinogen makes fibrin threads, which serve as adhesive in binding platelets, red blood cells, and other molecules together, to stop the blood flow.

**(Slide 20)** Main Functions of Plasma Proteins:

**Protein Nutrition:** Plasma proteins perform as the main source by providing a course, whenever the require arises.

**Osmotic Pressure and water balance:** Plasma proteins apply an osmotic pressure of about 25 mm of Hg and therefore play a significant part in balancing a proper water percentage in between the tissues and home-blood. Plasma albumin is mostly accountable for this function because of its low molecular weight and the quantitative amount over other proteins. However, during the situation of protein loss from the human body as be found in kidney diseases, a huge percentage of water moves to the tissues as a result edema may cause.

**Buffering action:** Plasma proteins play an important role in maintaining the pH of the body, i.e. seven, by performing asampholytes process.

**Transport of Lipids:** One of the most crucial works of plasma proteins is to deliver lipids and lipid soluble substances in the whole human body. Fatty acids and bilirubin are carried mainly by albumin, while on the other side cholesterol and phospholipids are transferred by the lipoproteins exist in β-globulins also transport fat-soluble vitamins.

**Transport of other complexes salts:** If we considering to lipids, plasma proteins also helping in transporting various metals and other substances, i.e. thyroxine etc.

**Blood Coagulation:** Prothrombin that present in α2-globulin fraction and fibrinogen, take part in the blood clotting.

**(Slide 21)** The density and viscosity of blood depend mainly on the number of formed elements and normally fluctuate within narrow limits. In humans, the density of whole blood is 1.05–1.06 g / cm3 (grams per cubic centimeters), plasma is 1.02–1.03 g / cm3, and that of cells is 1.09 g / cm3. The difference in density allows whole blood to be separated into plasma and blood cells, which is easily achieved by centrifugation. Erythrocytes make up 44%, leukocytes and platelets - 1% of the total blood volume.

**(Slide 22)** The osmotic pressure of blood, at 37 ° C equal to 7.63 atm. Is determined by its osmotic concentration, i.e. the sum of all particles − molecules, ions, colloidal particles, located in a unit of volume, mainly electrolytes that are part of it; in plasma − with sodium and chlorine ions, in erythrocytes − potassium and chlorine, as well as proteins present in the blood. This value is maintained by physiological mechanisms with very great constancy. In medical research, the value of osmotic pressure is rarely investigated, much more often they use the equivalent concept of osmotic concentration, which is determined by the magnitude of the depression (lowering) of the freezing point of the liquid under study in comparison with water. Normally, this value is 0.55-0.56, which corresponds to 0.27-0.31 mol / l or 270-310 mmol / l.

The primary force driving fluid transport between the capillaries and tissues is hydrostatic pressure, which can be defined as the pressure of any fluid enclosed in a space. Blood hydrostatic pressure is the force exerted by the blood confined within blood vessels or heart chambers. Even more specifically, the pressure exerted by blood against the wall of a capillary is called capillary hydrostatic pressure (CHP), and is the same as capillary blood pressure. CHP is the force that drives fluid out of capillaries and into the tissues.

**(Slide 23)** Oncotic pressure, or colloid osmotic-pressure, is a form of osmotic pressure induced by the proteins, notably albumin, in a blood vessel's plasma (blood/liquid) that displaces water molecules, thus creating a relative water molecule deficit with water molecules moving back into the circulatory system within the lower venous pressure end of capillaries. It has the opposing effect of both hydrostatic blood pressure pushing water and small molecules out of the blood into the interstitial spaces within the arterial end of capillaries and interstitial colloidal osmotic pressure. These interacting factors determine the partition balancing of total body extracellular water between the blood plasma and the larger extracellular water volume outside the blood stream.

**(Slide 24) Video. Capillary exchange.**

**(Slide 25)** Proper physiological functioning depends on a very tight balance between the concentrations of acids and bases in the blood. Acid-balance balance is measured using the pH scale, as shown in Figure 26.4.1. A variety of buffering systems permits blood and other bodily fluids to maintain a narrow pH range, even in the face of perturbations. A buffer is a chemical system that prevents a radical change in fluid pH by dampening the change in hydrogen ion concentrations in the case of excess acid or base. Most commonly, the substance that absorbs the ions is either a weak acid, which takes up hydroxyl ions, or a weak base, which takes up hydrogen ions.

**(Slide 26)** The buffer systems in the human body are extremely efficient, and different systems work at different rates. It takes only seconds for the chemical buffers in the blood to make adjustments to pH. The respiratory tract can adjust the blood pH upward in minutes by exhaling carbon dioxide from the body. The renal system can also adjust blood pH through the excretion of hydrogen ions (H+) and the conservation of bicarbonate, but this process takes hours to days to have an effect.

The buffer systems functioning in blood plasma include plasma proteins, phosphate, and bicarbonate and carbonic acid buffers. The kidneys help control acid-base balance by excreting hydrogen ions and generating bicarbonate that helps maintain blood plasma pH within a normal range. Protein buffer systems work predominantly inside cells.

**(Slide 27) Protein Buffers in Blood Plasma and Cells**

Nearly all proteins can function as buffers. Proteins are made up of amino acids, which contain positively charged amino groups and negatively charged carboxyl groups. The charged regions of these molecules can bind hydrogen and hydroxyl ions, and thus function as buffers. Buffering by proteins accounts for two-thirds of the buffering power of the blood and most of the buffering within cells.

**(Slide 28) Hemoglobin as a Buffer**

Hemoglobin is the principal protein inside of red blood cells and accounts for one-third of the mass of the cell. During the conversion of CO2 into bicarbonate, hydrogen ions liberated in the reaction are buffered by hemoglobin, which is reduced by the dissociation of oxygen. This buffering helps maintain normal pH. The process is reversed in the pulmonary capillaries to re-form CO2, which then can diffuse into the air sacs to be exhaled into the atmosphere. This process is discussed in detail in the chapter on the respiratory system.

**(Slide 29) Phosphate Buffer**

Phosphates are found in the blood in two forms: sodium dihydrogen phosphate (Na2H2PO4−), which is a weak acid, and sodium monohydrogen phosphate (Na2HPO42-), which is a weak base. When Na2HPO42- comes into contact with a strong acid, such as HCl, the base picks up a second hydrogen ion to form the weak acid Na2H2PO4− and sodium chloride, NaCl. When Na2HPO42− (the weak acid) comes into contact with a strong base, such as sodium hydroxide (NaOH), the weak acid reverts back to the weak base and produces water. Acids and bases are still present, but they hold onto the ions.

HCl + Na2HPO4→NaH2PO4 + NaCl

(strong acid) + (weak base) → (weak acid) + (salt)

NaOH + NaH2PO4→Na2HPO4 + H2O

(strong base) + (weak acid) → (weak base) + (water)

**(Slide 30) Bicarbonate-Carbonic Acid Buffer**

The bicarbonate-carbonic acid buffer works in a fashion similar to phosphate buffers. The bicarbonate is regulated in the blood by sodium, as are the phosphate ions. When sodium bicarbonate (NaHCO3), comes into contact with a strong acid, such as HCl, carbonic acid (H2CO3), which is a weak acid, and NaCl are formed. When carbonic acid comes into contact with a strong base, such as NaOH, bicarbonate and water are formed.

NaHCO3 + HCl → H2CO3+NaCl

(sodium bicarbonate) + (strong acid) → (weak acid) + (salt)

H2CO3 + NaOH→HCO3- + H2O

(weak acid) + (strong base)→(bicarbonate) + (water)

As with the phosphate buffer, a weak acid or weak base captures the free ions, and a significant change in pH is prevented. Bicarbonate ions and carbonic acid are present in the blood in a 20:1 ratio if the blood pH is within the normal range. With 20 times more bicarbonate than carbonic acid, this capture system is most efficient at buffering changes that would make the blood more acidic. This is useful because most of the body’s metabolic wastes, such as lactic acid and ketones, are acids. Carbonic acid levels in the blood are controlled by the expiration of CO2 through the lungs. In red blood cells, carbonic anhydrase forces the dissociation of the acid, rendering the blood less acidic. Because of this acid dissociation, CO2 is exhaled (see equations above). The level of bicarbonate in the blood is controlled through the renal system, where bicarbonate ions in the renal filtrate are conserved and passed back into the blood. However, the bicarbonate buffer is the primary buffering system of the IF surrounding the cells in tissues throughout the body.

CO2 + H2O ↔ H2CO3 ↔ H+ + HCO3–

**(Slide 31) Video. The Blood Buffer System.**

**(Slide 32)** Each milliliter of blood on average contains about 5 billion erythrocytes (red blood cells, or RBCs), commonly reported clinically in a red blood cell count as 5 million cells per cubic millimeter. Two anatomic features of erythrocytes contribute to the efficiency with which they transport oxygen. First, erythrocytes are flat, disc-shaped cells indented in the middle on both sides, like a doughnut with a flattened center instead of a hole (that is, they are biconcave discs). This unique shape provides a larger surface area for diffusion of oxygen from the plasma across the membrane into the erythrocyte than a spherical cell of the same volume would.

**(Slide 33)** Hemoglobin is found only in red blood cells. A hemoglobin molecule has two parts: (1) the globin portion, a protein made up of four highly folded polypeptide chains, and (2) four iron-containing, nonprotein groups known as heme groups, each of which is bound to one of the polypeptides. Each of the four iron atoms can combine reversibly with one molecule of oxygen; thus, each hemoglobin molecule can pick up four oxygen passengers in the lungs. Because oxygen is poorly soluble in the plasma, 98.5% of the oxygen carried in the blood is bound to hemoglobin. Hemoglobin is a pigment (that is, it is naturally colored). Because of its iron content, it appears reddish when combined with oxygen and bluish when deoxygenated. Thus, fully oxygenated arterial blood is red, and venous blood, which has lost some of its oxygen load at the tissue level, has a bluish cast.

**Erythropoiesis is controlled by erythropoietin from the kidneys.**

**(Slide 34)** Because oxygen transport in the blood is the erythrocytes’ main function, you might logically suspect that the primary stimulus for increased erythrocyte production would be reduced oxygen delivery to the tissues. You would be correct, but low oxygen levels do not stimulate erythropoiesis by acting directly on the red bone marrow. Instead, reduced oxygen delivery to the kidneys stimulates them to secrete the hormone erythropoietin into the blood, and this hormone in turn stimulates erythropoiesis by the bone marrow. This increased erythropoietic activity elevates the number of circulating RBCs, thereby increasing oxygen-carrying capacity of the blood and restoring oxygen delivery to the tissues to normal. Once normal oxygen delivery to the kidneys is achieved, erythropoietin secretion is turned down until needed again. In this way, erythrocyte production is normally balanced against destruction or loss of these cells so that oxygen-carrying capacity in the blood stays fairly constant.

**(Slide 35)** Leukocytes (white blood cells, or WBCs) are the mobile units of the body’s immune defense system. Immunity is the body’s ability to resist or eliminate potentially harmful foreign materials or abnormal cells. The first line of defense against foreign invaders is the epithelial barriers that surround the outer surface of the body (the skin) and line the body cavities (such as the digestive tract and lungs) that are in contact with the external environment. These epithelial barriers are not part of the immune system. We discuss their roles in the body’s overall defense mechanisms aft er examining the immune system in detail.

**(Slide 36)** Leukocytes and their derivatives, along with a variety of plasma proteins, make up the immune system, an internal defense system that recognizes and either destroys or neutralizes materials that are not “normal self,” either foreign materials that have entered the body or abnormal cells that have arisen within the body. Specifically, for the immune system:

1. Defends against invading pathogens (disease-producing microorganisms such as bacteria and viruses).

2. Functions as a “cleanup crew” that removes worn-out cells (such as aged red blood cells) and tissue debris (for example, tissue damaged by trauma or disease), paving the way for wound healing and tissue repair.

3. Identifies and destroys abnormal or mutant cells that arise in the body. This function, termed immune surveillance, is the primary internal-defense mechanism against cancer.

**(Slide 37)** Leukocytes primarily function as defense agents outside the blood. To carry out their functions, leukocytes largely use a “seek out and attack” strategy; that is, they go to sites of invasion or tissue damage. The main reason WBCs are in the blood is for rapid transport from their site of production or storage to wherever they are needed. Unlike erythrocytes, leukocytes are able to exit the blood by assuming amoeba-like behavior to wriggle through narrow capillary pores and crawl to assaulted areas (see ● Figure 11-14, p. 314). As a result, the immune system’s effector cells are widely dispersed throughout the body and can defend in any location.

**(Slide 38) There are five types of leukocytes.** Leukocytes lack hemoglobin (in contrast to erythrocytes), so they are colorless (that is, “white”) unless specifically stained for microscopic visibility. Unlike erythrocytes, which are of uniform structure, identical function, and constant number, leukocytes vary in structure, function, and number. There are five types of circulating leukocytes − neutrophils, eosinophils, basophils, monocytes, and lymphocytes − each with a characteristic structure and function. They are all somewhat larger than erythrocytes.

Granulocytes and Agranulocytes

**(Slide 39)** The five types of leukocytes fall into two main categories, depending on the appearance of their nuclei and the presence or absence of granules in their cytoplasm when viewed microscopically. Neutrophils, eosinophils, and basophils are categorized as polymorphonuclear (meaning “many-shaped nucleus”) granulocytes (meaning “granule-containing cells”). Their nuclei are segmented into several lobes of varying shapes, and their cytoplasm contains an abundance of membrane-enclosed granules. The three types of granulocytes are distinguished on the basis of the varying affinity of their granules for dyes: eosinophils have an affinity for the red dye eosin, basophils preferentially take up a basic blue dye, and neutrophils are neutral, showing no dye preference. Monocytes and lymphocytes are known as mononuclear (meaning “single nucleus”) agranulocytes (meaning “cells lacking granules”). Both have a single, large, nonsegmented nucleus and few granules. Monocytes are the larger of the two and have an oval or kidney-shaped nucleus. Lymphocytes, the smallest of the leukocytes, characteristically have a large spherical nucleus that occupies most of the cell.

**Functions and Life Spans of Leukocytes**

**(Slide 40)** The following are the functions and life spans of the granulocytes: **Neutrophils are phagocytic specialists.** They engulf and destroy bacteria intracellularly. As a further assault, neutrophils can also act like “suicide bombers,” undergoing an unusual type of programmed cell death in which they which use vital cellular materials to prepare a web of fibers dubbed neutrophil extracellular traps (NETs), which they release into the ECF on their death. These fibers contain bacteria-killing chemicals, enabling NETs to trap and then destroy bacteria extracellularly. Neutrophils invariably are the first defenders on the scene of bacterial invasion. Furthermore, they scavenge to clean up debris. As might be expected in view of these functions, an increase in circulating neutrophils typically

accompanies acute bacterial infections.

**(Slide 41) Eosinophils** are specialists of another type. An increase in circulating eosinophils is associated with allergic conditions (such as asthma and hay fever) and with internal parasite infestations (for example, worms). Eosinophils obviously cannot engulf a larger parasitic worm, but they do attach to the worm and secrete substances that kill it.

**(Slide 42) Basophils** are the least numerous and most poorly understood of the leukocytes. They are quite similar structurally and functionally to mast cells, which never circulate in the blood but instead are dispersed in connective tissue throughout the body. Both basophils and mast cells synthesize and store histamine and heparin, powerful chemical substances that can be released on appropriate stimulation. Histamine release is important in allergic reactions, whereas heparin speeds up removal of fat particles from the blood after a fatty meal. Heparin can also prevent clotting of blood samples drawn for clinical analysis and is used extensively as an anticoagulant drug, but whether it plays a physiologic role as an anticoagulant is still debated. Once released into the blood from the bone marrow, a granulocyte usually stays in transit in the blood for less than a day before leaving the blood vessels to enter the tissues, where it survives another 3 to 4 days unless it dies sooner in the line of duty. By comparison, the functions and life spans of the agranulocytes are as follows:

**(Slide 43) Monocytes**, like neutrophils, become professional phagocytes. They emerge from the bone marrow while still immature and circulate for only a day or two before settling down in various tissues throughout the body. At their new residences, monocytes continue to mature and greatly enlarge, becoming the large tissue phagocytes known as macrophages (macro means “large”; phage means “eater”). A macrophage’s life span may range from months to years unless it is destroyed sooner while performing its phagocytic activity. A phagocytic cell can ingest only a limited amount of foreign material before it succumbs.

**(Slide 44) Lymphocytes** provide immune defense against targets for which they are specifically programmed. There are two types of lymphocytes, B and T lymphocytes (B and T cells), which look alike. B lymphocytes produce antibodies, which circulate in the blood and are responsible for antibody-mediated, or humoral, immunity. An antibody binds with and marks for destruction (by phagocytosis or other means) the specific kinds of foreign matter, such as bacteria, that induced production of the antibody. T lymphocytes do not produce antibodies; instead, they directly destroy their specific target cells by releasing chemicals that punch holes in the victim cell, a process called cell mediated immunity. The target cells of T cells include body cells invaded by viruses and cancer cells. Lymphocytes live for about 100 to 300 days. Only a small part of the total lymphocytes are in transit in the blood at any given moment. Most continually recycle among the blood, lymph, and lymphoid tissues. Lymphoid tissues, such as the lymph nodes and tonsils, are lymphocyte-containing tissues that produce, store, or process lymphocytes.

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PHYSIOLOGY OF THE BLOOD.

Questions that we will analyze for a lesson on this topic:

1. The concept of the blood system.
2. Blood functions.
3. Composition of blood.
4. Hematocrit.
5. Plasma composition.
6. Basic physicochemical constants of blood.
7. Blood buffer systems.
8. Blood cells and their function.

Lauralee Sherwood. Fundamentals of Human Physiology. P. 106 – 127.

**Questions that we will analyze for a lesson on the topic «Private physiology of the central nervous system»:**

1. The role of the spinal cord in the regulation of body functions.
2. Medulla oblongata and pons: centers and corresponding reflexes.
3. Midbrain: basic structures and their functions, static and statokinetic reflexes. The state of the muscle tone of the mesencephalic animal.
4. Reticular formation and its functions.
5. Cerebellum and its functions.

Finish for today

The full lecture is at the indicated website.

**Thank you for attention**