Formed elements of blood chart

The production of formed elements, or blood cells, is called hemopoiesis. Before birth, hemopoiesis occurs primarily in the liver and spleen, but some cells develop in the thymus, lymph nodes, and red bone marrow. After birth, most production is limited to red bone marrow in specific regions, but some white blood cells are produced in lymphoid tissue. All types of formed elements develop from a single cell type — stem cell (pleuripotential cells or hemocytoblasts). Seven different cell lines, each controlled by a specific growth factor, develop from the hemocytoblast. When a stem cell divides, one of the "daughters" remains a stem cell and the other becomes a precursor cell, either a lymphoid cell or a myeloid cell. These cells continue to mature into various blood cells. Leukemia can develop at any point in cell differentiation. The illustration below shows the development of the formed elements of the blood. « Previous (Composition of the Blood)Next (Review) » 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. Plasma The watery fluid portion of blood (90 percent water) in which the corpuscular elements are suspended. It transports nutrients as well as wastes throughout the body. Various compounds, including proteins, electrolytes, carbohydrates, minerals, and fats, are dissolved in it. Formed Elements The formed elements are cells and cell fragments suspended in the plasma. The three classes of formed elements are the erythrocytes (red blood cells), leukocytes (white blood cells), and the thrombocytes (platelets). Erythrocytes (red blood cells) Erythrocytes, or red blood cells, are the most numerous of the formed elements. Erythrocytes are tiny biconcave disks, thin in the middle and thicker around the periphery. The shape provides a combination of flexibility for moving through tiny capillaries with a maximum surface area for the diffusion of gases. The primary function of erythrocytes is to transport oxygen and, to a lesser extent, carbon dioxide. Leukocytes (white blood cells) Leukocytes, or white blood cells, are generally larger than erythrocytes, but they are fewer in number. Even though they are considered to be blood cells, leukocytes do most of their work in the tissues. They use the blood as a transport medium. Some are phagocytic, others produce antibodies; some secrete histamine and heparin, and others neutralize histamine. Leukocytes are able to move through the capillary walls into the tissue spaces, a process called diapedesis.In the tissue spaces they provide a defense against organisms that cause disease and either promote or inhibit inflammatory responses. There are two main groups of leukocytes in the blood. The cells that develop granules in the cytoplasm are called granulocytes and those that do not have granules are called agranulocytes. Neutrophils, eosinophils, and basophils are granulocytes. Monocytes and lymphocytes are agranulocytes. Neutrophils, the most numerous leukocytes, are phagocytic and have light-colored granules. Eosinophils have granules and help counteract the effects of histamine. Basophils secrete histomine and heparin and have blue granules. In the tissues, they are called mast cells. Lymphocytes are agranulocytes that have a special role in immune processes. Some attack bacteria directly; others produce antibodies. Thrombocytes (platelets) Thrombocytes, or platelets, are not complete cells, but are small fragments of very large cells called megakaryocytes. Megakaryocytes develop from hemocytoblasts in the red bone marrow. Thrombocytes become sticky and clump together to form platelet plugs that close breaks and tears in blood vessels. They also initiate the formation of blood clots. « Previous (Anatomy)Next (Blood Cell Lineage) » Last update: Nov 27th, 2017 Learn anatomy faster and remember everything you learn Introduction to the Formed Elements of the Blood:The formed elements are cells, cell remnants, and cell fragments in the blood. Red Blood Cells (RBCs or erythrocytes) make up more than 95% of the formed elements. A red blood cell in a section of capillary.Because they lack a nucleus and organelles, most RBCs in the bloodstream are not fully functional cells. Instead, they serve as temporary, hemoglobin-filled containers that transport oxygen throughout the body.Also included in the formed elements are five types of white blood cells (WBCs or leukocytes). They are part of the immune system and that helps protect the body from foreign invaders. The WBCs are identified and classified based on their stained appearance.Three of the WBCs have cytoplasmic granules and are called granulocytes: Neutrophils A neutrophil in a section of capillary. Eosinophils An eosinophils in a section of capillary. Basophils A basophil in a section of capillary.The remaining two types of WBCs do not have cytoplasmic granules and are classified as agranulocytes: Lymphocyte A lymphocyte in a section of capillary. MonocytesLearn to identify cells under the microscope with these histology quizzes and labelling exercises. A monocyte in a section of capillary.The smalled formed elements are called platelets (thrombocytes). These are actually cytoplasmic fragments that pinch from large cells called megakaryocytes. Phospholipids released from platelets help initiate the clotting process. Platelets in a section of capillary. Human blood is made of different type of cells suspended in a solution called plasma. 55% of blood volume is plasma and 45% comprises of cells and solid constituents. These cells are also called corpuscles or formed elements. Blood cells are formed in the bone marrow of the long bones and in the lymph nodes.The formed elements of the blood comprises of three components:1. Erythrocytes (also called red blood cells or RBCs)2. Leukocytes (also called white blood cells or WBCs)3. Thrombocytes (also called platelets)Blood countErythrocytes• Males contain 4.5 to 6 million red blood cells per ml of their blood.• Females contain 4 to 5.5 million red blood cells per ml of their blood.Leukocytes• Human blood contains 4 to 11 thousand white blood cells per ml of blood.Thrombocytes• Human blood contains 200 to 500 thousand platelets in one ml of their blood.FunctionsRed blood cells are the most common blood cells and aid in transporting oxygen to the tissues for respiration, and carbon dioxide from the tissues back to the lungs for expulsion. RBCs are able to do this by binding oxygen to iron-containing compounds called hemoglobin, which is responsible for their red color. RBCs lack nucleus and most organelles. They live for only 100–120 days, and therefore, need to be produced constantly. As per one estimate, a human being makes 2.4 million erythrocytes every second, through a process known as erythropoiesis.White blood cells protect the body against infectious. They are found throughout the blood and lymphatic system. They are of five different types: neutrophils, eosinophils, basophils, lymphocytes, and monocytes. Monocytes and neutrophils are phagocytic, while lymphocytes, (B cells, T cells, and NK cells) have other immune related functions.Platelets function to stop bleeding by creating blood clots through a process called thrombogenesis. They do so by adhesion, activation, and aggregation in response to vascular injuries. They bind to special receptors at the site of injury, get activated, and aggregate to form clumps that plug the injury. Sponsored link The normal lab values chart shows the standard values of various parameters that need to be monitored to determine the health status of a person. Sponsored link Whenever there is a patient admitted to the hospital, there are always routine examinations that the patient should undergo to provide the baseline data needed by the physicians to commence treatment. Some patients are subjected to laboratory examinations for the proper detection and screening of their conditions. The normal lab values chart is important for the health care providers because it helps them determine whether the results are normal or if there are abnormalities. The following are the normal lab values chart for some of the common tests performed for screening or diagnosis. Normal lab values chart for complete blood count Complete blood count (CBC) is the test that measures the amount of red blood cells, white blood cells, platelets and other components of the blood.The CBC can aid the health care provider as well as the patient to check the status of the formed elements in the blood. Blood components Normal value Red blood cells 4- 6 M/ µL Hemoglobin (male) 14- 18 g/ dL Hemoglobin (female) 12- 16 g/ dL Hematocrit (male) 39- 54 % Hematocrit (female) 34- 47% Mean corpuscular volume (MCV) 78 – 98 fL Mean corpuscular hemoglobin (MCH) 27 – 35 pg Mean corpuscular hemoglobin concentration (MCHC) 31 – 37% White blood cells 5000- 10000 mm^3 Basophils 0 – 1% Eosinophils 1-5% Neutrophils 50 – 81% Lymphocytes 14- 44% Monocytes 2-6% Normal lab values chart for Electrolytes Electrolytes are needed by the body because they serve to keep it in astate of equilibrium. Electrolytes help the cells, brain, nerves and muscles to function effectively and also control the level of water in the body. Electrolytes Normal values Sodium 135 – 145 mEq/L Potassium 3.5 – 5.5 mEq/L Phosphorous 2.2 – 4.8 mg/dL Magnesium 1.5 – 2.5 mg/dL Iron 52 – 169 µg/dL Chloride 96 – 112 mEq/L Calcium 8 – 11 mg/dL Normal lab values chart for blood coagulation When a patient is given warfarin and heparin medications, he or she is observed for signs of bleeding.The normal lab values chart for blood coagulation is referred to for any signs of improvement or complications happening with the patient. Sponsored link Normal values Platelets 140,000 – 450,000 / ml Prothrombin time (for warfarin medication) 11 – 16 seconds Activated Partial Thromboplastin Time (for heparin medication) 30 – 45 seconds Fibrinogen 160 – 450 mg/dL Bleeding Time 3 – 9 minutes Thrombin time 11 – 15 seconds Plasminogen 62 – 130% Normal lab values chart for cardiac markers Cardiac markers are important indicators for patients at risk of myocardial infarction. Seeing the lab values chart for the normal ranges of the cardiac markers would assist the health care provider in determining if there is any danger of myocardial infarction. Cardiac Markers Normal Values Troponin I 0 – 0.1 ng/ml onset: 4-6 hours peak: 12-24 hours returns to normal: 4-7 days Troponin T 0 – 0.2 ng/ml onset: 3-4 hrs peak: 10-24 hrs returns to normal: 10-14 days Creatinine Kinase-MB (CK-MB) Males: 50- 325 mu/ml Females: 50- 250 mu/ ml Onset: 3- 6 hours Peak: 12- 18 hours Returns to normal: 3-4 days Myoglobin 10 – 95 ng/ml onset: 1-3 hours peak: 6-10 hours returns to normal: 12-24 hrs Lactic Dehydrogenase 100- 225 mU/ml onset: 12 hours peak: 48 hours returns to normal: 10- 14 days Aspartase Aminotransferase (AST) 7- 40 mu/ml Onset: 4- 6 hours Peak: 24- 36 hours Returns to normal: 4 to 7 days Normal lab values chart for urine One of the important outputs of the body is urine. Urine can aid us in finding out how well the kidneys are working.Urine test or urinalysis is also one of the most common laboratory tests ordered by doctors as part of the diagnostic procedures for many illnesses. The normal lab values chart for urine is crucial in interpreting the results and making a diagnosis. Normal Values color Clear to straw color Specific gravity 1.003 – 1.040 pH 4.6 – 8.0 Creatinine 1 – 2 g / 24 hr Creatine Clearance (Male) 100 – 140 mL / min Creatine Clearance (Female) 80 – 130 mL / min Osmolality 80 – 1300 mOsm/L Protein 1 – 15 mg/dl BUN 6- 23 mg/dl The normal lab values chart does help both the physician and the patientin identifying if the condition is considered normal or not; however, the normal lab values chart can have variations from one laboratory to another. The best thing to do to avoid misinterpretations of the results is to check the standards of the laboratory where the test was conducted. The health care provider must know that the result of the laboratory examination is not the sole diagnostic factor required to confirm the condition of the patient. Sponsored link By the end of this section, you will be able to: Describe the formation of the formed element components of blood Trace the generation of the formed elements of blood from bone marrow stem cells Discuss the role of hemopoietic growth factors in promoting the production of the formed elements The lifespan of the formed elements is very brief. Although one type of leukocyte called memory cells can survive for years, most erythrocytes, leukocytes, and platelets normally live only a few hours to a few weeks. Thus, the body must form new blood cells and platelets quickly and continuously. If you donate a unit of blood during a blood drive (approximately 475 mL, or about 1 pint), your body typically replaces the donated plasma within 24 hours, but it takes about 4 to 6 weeks to replace the blood cells. This restricts the frequency with which donors can contribute their blood. The process by which this replacement occurs is called hemopoiesis, or hematopoiesis (from the Greek root haima- = “blood”; -poiesis = “production”). Prior to birth, hemopoiesis occurs in a number of tissues, beginning with the yolk sac of the developing embryo, and continuing in the fetal liver, spleen, lymphatic tissue, and eventually the red bone marrow. Following birth, most hemopoiesis occurs in the red marrow, a connective tissue within the spaces of spongy (cancellous) bone tissue. In children, hemopoiesis can occur in the medullary cavity of long bones; in adults, the process is largely restricted to the cranial and pelvic bones, the vertebrae, the sternum, and the proximal epiphyses of the femur and humerus. Throughout adulthood, the liver and spleen maintain their ability to generate the formed elements. This process is referred to as extramedullary hemopoiesis (meaning hemopoiesis outside the medullary cavity of adult bones). When a disease such as bone cancer destroys the bone marrow, causing hemopoiesis to fail, extramedullary hemopoiesis may be initiated. All formed elements arise from stem cells of the red bone marrow. Recall that stem cells undergo mitosis plus cytokinesis (cellular division) to give rise to new daughter cells. One of these daughter cells remains a stem cell and the other differentiates into one of any number of diverse cell types. Stem cells may be viewed as occupying a hierarchal system, with some loss of the ability to diversify at each step. The totipotent stem cell is the zygote, or fertilized egg. The totipotent (toti- = “all”) stem cell gives rise to all cells of the human body. The next level is the pluripotent stem cell, which gives rise to multiple types of cells of the body and some of the supporting fetal membranes. Beneath this level, the mesenchymal cell is a stem cell that develops only into types of connective tissue, including fibrous connective tissue, bone, cartilage, and blood, but not epithelium, muscle, and nervous tissue. One step lower on the hierarchy of stem cells is the hemopoietic stem cell, or hemocytoblast. All of the formed elements of blood originate from this specific type of cell. Hemopoiesis begins when the hemopoietic stem cell is exposed to appropriate chemical stimuli collectively called hemopoietic growth factors, which prompt it to divide and differentiate. One daughter cell remains a hemopoietic stem cell, allowing hemopoiesis to continue. The other daughter cell becomes either of two types of more specialized stem cells (Figure 18.2.1): Lymphoid stem cells give rise to a class of leukocytes known as lymphocytes, which include the various T cells, B cells, and natural killer (NK) cells, all of which function in immunity. However, hemopoiesis of lymphocytes progresses somewhat differently from the process for the other formed elements. In brief, lymphoid stem cells quickly migrate from the bone marrow to lymphatic tissues, including the lymph nodes, spleen, and thymus, where their production and differentiation continues. B cells are so named since they mature in the bone marrow, while T cells mature in the thymus. Myeloid stem cells give rise to all the other formed elements, including the erythrocytes; megakaryocytes that produce platelets; and a myeloblast lineage that gives rise to monocytes and three forms of granular leukocytes: neutrophils, eosinophils, and basophils. Figure 18.2.1. Hematopoietic System of Bone Marrow. Hemopoiesis is the proliferation and differentiation of the formed elements of blood. Lymphoid stem cells give rise to lymphocytes including T cells, B cells, and natural killer (NK) cells. Myeloid stem cells give rise to all the other formed elements. Lymphoid and myeloid stem cells do not immediately divide and differentiate into mature formed elements. As you can see in Figure 1, there are several intermediate stages of precursor cells, many of which can be recognized by their names, which have the suffix -blast. For instance, megakaryoblasts are the precursors of megakaryocytes, and proerythroblasts become reticulocytes, which eject their nucleus and most other organelles before maturing into erythrocytes. Development from stem cells to precursor cells to mature cells is initiated by hemopoietic growth factors. These include the following: Erythropoietin (EPO) is a glycoprotein hormone secreted by the interstitial fibroblast cells of the kidneys in response to low oxygen levels. It prompts the production of erythrocytes. Some athletes use synthetic EPO as a performance-enhancing drug (called blood doping) to increase RBC counts and subsequently increase oxygen delivery to tissues throughout the body. EPO is a banned substance in most organized sports, but it is also used medically in the treatment of certain anemia, specifically those triggered by certain types of cancer, and other disorders in which increased erythrocyte counts and oxygen levels are desirable. Thrombopoietin, another glycoprotein hormone, is produced by the liver and kidneys. It triggers the development of megakaryocytes into platelets. Cytokines are glycoproteins secreted by a wide variety of cells, including red bone marrow, leukocytes, macrophages, fibroblasts, and endothelial cells. They act locally as autocrine or paracrine factors, stimulating the proliferation of progenitor cells and helping to stimulate both nonspecific and specific resistance to disease. There are two major subtypes of cytokines known as colony-stimulating factors and interleukins. Colony-stimulating factors (CSFs) are glycoproteins that act locally, as autocrine or paracrine factors. Some trigger the differentiation of myeloblasts into granular leukocytes, namely, neutrophils, eosinophils, and basophils. These are referred to as granulocyte CSF or G-CSFs. A different CSF induces the production of monocytes, called monocyte CSF or M-CSFs. Both granulocytes and monocytes are stimulated by GM-CSF; granulocytes, monocytes, platelets, and erythrocytes are stimulated by multi-CSF. Synthetic forms of these hormones are often administered to patients with various forms of cancer who are receiving chemotherapy to revive their WBC counts. Interleukins are another class of cytokine signaling molecules important in hemopoiesis. They were initially thought to be secreted uniquely by leukocytes and to communicate only with other leukocytes, and were named accordingly, but are now known to be produced by a variety of cells including bone marrow and endothelium. Researchers now suspect that interleukins may play other roles in body functioning, including differentiation and maturation of cells, producing immunity, and inflammation. To date, close to 40 interleukins have been identified, and more are likely to be discovered. They are generally numbered IL-1, IL-2, IL-3, etc. In its original intent, the term blood doping was used to describe the practice of injecting supplemental RBCs into an individual, to enhance performance in a sport. Additional RBCs would deliver more oxygen to the tissues, providing extra aerobic capacity, referred to as VO2 max. The source of the cells was either from the recipient (autologous) or from a donor with compatible blood (homologous). This practice was aided by the well-developed techniques of harvesting, concentrating, and freezing of the RBCs that could be later thawed and injected, yet still retain their functionality. These practices are considered illegal in virtually all sports and run the risk of infection, significantly increasing the viscosity of the blood, and the potential for transmission of blood-borne pathogens if the blood was collected from another individual. With the development of synthetic EPO in the 1980s, it became possible to provide additional RBCs by artificially stimulating RBC production in the bone marrow. Originally developed to treat patients suffering from anemia, renal failure, or cancer treatment, large quantities of EPO can be generated by recombinant DNA technology. Synthetic EPO is injected under the skin and can increase hematocrit for many weeks. It may also induce polycythemia and raise hematocrit to 70 or greater. This increased viscosity raises the resistance of the blood and forces the heart to pump more powerfully; in extreme cases, it has resulted in death. Other drugs such as cobalt II chloride have been shown to increase natural EPO gene expression. Blood doping has become problematic in many sports, especially cycling. Lance Armstrong, winner of seven Tour de France and many other cycling titles, was stripped of his victories and admitted to blood doping in 2013. For certain medical conditions a healthcare provider could order a bone marrow biopsy, a diagnostic test of a sample of red bone marrow, or a bone marrow transplant, a treatment in which a donor’s healthy bone marrow—and its stem cells—replaces the faulty or damaged bone marrow of a patient. These tests and procedures are often used to assist in the diagnosis and treatment of various severe forms of anemia, such as thalassemia major and sickle cell anemia, as well as some types of cancer, specifically leukemia. In the past, when a bone marrow sample or transplant was necessary, the procedure would have required inserting a large-bore needle into the region near the iliac crest of the pelvic bones. This location was preferred, since its location close to the body surface makes it more accessible, and it is relatively isolated from most vital organs. Unfortunately, the procedure is quite painful. Now, direct sampling of bone marrow can often be avoided. In many cases, stem cells can be isolated in just a few hours from a sample of a patient’s blood. The isolated stem cells are then grown in culture using the appropriate hemopoietic growth factors, and analyzed or sometimes frozen for later use. For an individual requiring a transplant, a matching donor is essential to prevent the immune system from destroying the donor cells—a phenomenon known as tissue rejection. To treat patients with bone marrow transplants, it is first necessary to destroy the patient’s own diseased marrow through radiation and/or chemotherapy. Donor bone marrow stem cells are then intravenously infused. From the bloodstream, they establish themselves in the recipient’s bone marrow. Through the process of hemopoiesis, the formed elements of blood are continually produced, replacing the relatively short-lived erythrocytes, leukocytes, and platelets. Hemopoiesis begins in the red bone marrow, with hemopoietic stem cells that differentiate into myeloid and lymphoid lineages. Myeloid stem cells give rise to most of the formed elements. Lymphoid stem cells give rise only to the various lymphocytes designated as B and T cells, and Natural Killer (NK) cells. Hemopoietic growth factors, including erythropoietin, thrombopoietin, colony-stimulating factors, and interleukins, promote the proliferation and differentiation of formed elements. bone marrow biopsy diagnostic test of a sample of red bone marrow bone marrow transplant treatment in which a donor’s healthy bone marrow with its stem cells replaces diseased or damaged bone marrow of a patient colony-stimulating factors (CSFs) glycoproteins that trigger the proliferation and differentiation of myeloblasts into granular leukocytes (basophils, neutrophils, and eosinophils) cytokines class of proteins that act as autocrine or paracrine signaling molecules; in the cardiovascular system, they stimulate the proliferation of progenitor cells and help to stimulate both nonspecific and specific resistance to disease erythropoietin (EPO) glycoprotein that triggers the bone marrow to produce RBCs; secreted by the kidney in response to low oxygen levels hemocytoblast hemopoietic stem cell that gives rise to the formed elements of blood hemopoiesis production of the formed elements of blood hemopoietic growth factors chemical signals including erythropoietin, thrombopoietin, colony-stimulating factors, and interleukins that regulate the differentiation and proliferation of particular blood progenitor cells hemopoietic stem cell type of pluripotent stem cell that gives rise to the formed elements of blood (hemocytoblast) interleukins signaling molecules that may function in hemopoiesis, inflammation, and specific immune responses lymphoid stem cells type of hemopoietic stem cells that gives rise to lymphocytes, including various T cells, B cells, and NK cells, all of which function in immunity myeloid stem cells type of hemopoietic stem cell that gives rise to some formed elements, including erythrocytes, megakaryocytes that produce platelets, and a myeloblast lineage that gives rise to monocytes and three forms of granular leukocytes (neutrophils, eosinophils, and basophils) pluripotent stem cell stem cell that derives from totipotent stem cells and is capable of differentiating into many, but not all, cell types totipotent stem cell embryonic stem cell that is capable of differentiating into any and all cells of the body; enabling the full development of an organism thrombopoietin hormone secreted by the liver and kidneys that prompts the development of megakaryocytes into thrombocytes (platelets)