

Blood

Components

- formed elements: erythrocytes, leucocytes, platelets
- plasma (serum + clotting factors) is over 90% water. Other constituents include proteins, ions (electrolytes), nutrients, gases, waste products et al.

Physical characteristics: Blood is viscous and has a temperature of about 38°. Arterial blood has a pH of 7.35 – 7.45.

Functions

- distribution functions: transport of O₂, nutrients, metabolic waste (urea, CO₂), and hormones
- regulatory functions: body temperature, pH, fluid volume
- protective functions: preventing blood loss, preventing infection (antibodies, WBC's, Complement)

Plasma is mostly water (90%) containing over 100 different dissolved solutes, mostly plasma proteins. Albumin is the most abundant plasma protein (58%). It is a carrier, assisting other molecules through the circulation, an important buffer, and helps maintain osmotic pressure. Globulins including antibodies account for about 38%. Serum refers to blood plasma without clotting factors.

Formed Elements

Erythrocytes, or RBC's, are anucleate, biconcave discs containing hemoglobin and function in the transport of respiratory gases. Hematocrit is the percentage of total blood volume made up of RBC's (usually about 45%)

Hemoglobin is made up of globin, a protein consisting of two α and two β polypeptide chains each of which is bound to a molecule of the pigment heme. O₂ binds easily and reversibly to the iron in the heme so each hemoglobin molecule can bind with four molecules of oxygen. CO₂ binds to the globin.

Blood cell formation is called hematopoiesis. All formed elements originate from stem cells found in the red bone marrow called hemocytoblasts. Some of these (proerythroblasts) are committed to becoming RBC's. Hypoxic conditions stimulate certain kidney cells to release erythropoietin hormone which is transported to the bone marrow and hastens the maturity of RBC's. During the maturation process, the nucleus and other organelles are ejected and become stippled reticulocytes which enter the bloodstream. Erythrocytes last about 4 months at which time they are engulfed by macrophages (WBC's) and are stripped of their iron for reuse. Some of the heme is degraded into bilirubin which is picked up by liver cells and secreted in bile.

Anemias

- hemorrhagic anemia refers to loss of blood from the vessels.
- hemolytic anemia refers to the rupture of RBC's.
- aplastic anemia is the inability of bone marrow to manufacture RBC's.
- iron-deficiency anemia is the inadequate intake or absorption or loss of Fe necessary to make heme.
- pernicious anemia is a deficiency of vitamin B₁₂ necessary for DNA replication and cell division.
- thalassemias and sickle-cell anemia are genetic disorders affecting RBC's.

Erythrocytosis is a condition of having too many RBC's resulting in increased viscosity and possibly blocked capillaries.

Leucocytes

Leucocytes are nucleated and account for less than 1% of the total blood volume. The normally number from about 4,000 to 11,000 WBC's per mm³. A count of over 11,000/mm³ is referred to as leucocytosis. Some WBC's are capable of slipping through capillary walls by amoeboid motion (a process called diapedesis) where they are able to engulf infectious agents by phagocytosis.

There are two major categories of leukocytes: granulocytes (which have visible cytoplasmic granules) and agranulocytes.

Granulocytes

Neutrophils, whose cytoplasm stains a lilac color with a mixture of basic and acidic dyes, are the most numerous of the WBC's (about 60%). They are about twice the size of RBC's and have nuclei variably consisting of 3 to 6 lobes. (They are sometimes called polymorphonuclear leukocytes.) They are able to leave the bloodstream and enter infected tissue where they ingest and destroy bacteria. They increase dramatically with acute bacterial infections.

Eosinophils' cytoplasm stain red or orange with the acidic dye eosin and make up about 1 – 4% of all WBC's. They have a bilobed nucleus. Their major function is to produce toxic proteins against certain parasitic worms. They are also important in allergic responses by phagocytizing immune complexes.

Basophils' cytoplasm stain blue-purple with the basic dye methylene blue. They account for <1% of all WBC's and generally have a U- or S-shaped nucleus. Their numbers become elevated during allergic responses and certain types of cancer. They are important in the release of histamine during the inflammatory response.

Agranulocytes

Lymphocytes are the second most numerous of the WBC's (20 to 40%). Most are not found in the bloodstream but are enmeshed in lymphoid tissue where they are necessary for the specific immune response. T cells respond directly against infected cells. B cells give rise to plasma cells that produce antibodies. B cells also give rise to memory cells responsible for a more immediate reaction to the same antigen at the time of a later infection.

Monocytes are the largest of the WBC's and account for about 2 to 8% of the total. They have a kidney or U-shaped nucleus. During infections they leave the blood and migrate to infected tissue where they differentiate into macrophages that actively phagocytize pathogens. These may be "wandering" or "fixed". They also are important in activating lymphocytes.

In summary, WBC's fight off foreign substances by:

- releasing chemicals such as heparin (an anticoagulant) and histamine (a vasodilator)
- phagocytosis
- antibody production

The production of WBC's is called leucopoiesis. Hemocytoblasts may become lymphoid stem cells which are committed to becoming lymphocytes or myeloid stem cells committed to becoming all other types of WBC's.

Leukocytosis is a WBC count of greater than 11,000/mm³ and will occur normally in response to infection.

Leukocyte Disorders

- Leukopenia is an abnormally low WBC count.
- Leukemias are cancerous conditions involving WBC's.
- Infectious mononucleosis is a virus infection of B lymphocytes.usually seen in teens and young adults transmitted through infected saliva.
- AIDS is a viral infection of T lymphocytes.

Platelets

Platelets (or thrombocytes) are cell fragments of large cells called megakaryocytes. Their formation is regulated by the hormone thrombopoietin. Normal platelet count is 250,000 to 400,000 per mm³. Their function is to stick to exposed collagen in damaged blood vessel walls temporarily forming a seal to protect against blood loss. Aspirin makes platelets less sticky.

Blood Groups and Blood Transfusions

ABO blood groups are based on the presence or absence of two antigens or agglutinogens (specific glycoproteins on the RBC membrane surface) – type A and type B. There are also preformed antibodies called agglutinins that act against these two antigens that are found in the plasma – anti-A and anti-B. A person possesses agglutinins for the type of antigen that is **not** found on his RBC membrane. A person with neither antigen is Type O (and has both anti-A and anti-B agglutinins). A person with type A antigen is Type A (and has anti-B agglutinin). A person with type B antigen is Type B (and has anti-A agglutinin). A person with both antigens is Type AB (and has neither anti-A nor anti-B agglutinins). If RBC's with certain antigens are transfused into blood containing antibodies against those antigens, a clumping or agglutination will occur and may be fatal. Type O is called the universal donor, having no antigens on the membrane to cause a reaction. Type AB is called the universal receiver since no antibodies occur in the plasma.

People carrying the Rh antigen on their RBC membrane are called Rh⁺, those without the antigen are called Rh⁻. There are no preformed antibodies in the plasma but a transfusion involving Rh⁺ to an Rh- recipient stimulates antibody production in the recipient. No reaction takes place the first time because antibodies build up very slowly. But on subsequent exposures to the antigen, hemolysis occurs. Untreated, a second pregnancy involving an Rh- mother and an Rh⁺ fetus may result in abortion because of the mother's immediate immune response to the mixing of maternal and fetal blood. This is called hemolytic disease of the newborn.

Coagulation

Blood clotting is a complex, multistep process that results in:

- a complex substance called prothrombin activator is formed.
- Prothrombin activator converts a plasma protein called prothrombin into an enzyme called thrombin.
- Thrombin catalyzes the joining of fibrinogen molecules that are present in the plasma to a fibrin mesh which traps blood cells and effectively seals the hole until the blood vessel can be permanently repaired.

Factors that enhance clot formation are called clotting factors. Factors that inhibit clotting are called anticoagulants.

A clot that forms and persists in an unbroken blood vessel is called a thrombus. If the thrombus breaks away and floats freely in the bloodstream it is called an embolus. Vitamin K is necessary for the activation of prothrombin.

Disorders

- thrombocytopenia is a deficiency of circulating platelets
- impaired liver function occurs when the liver is unable to synthesize some of the clotting factors.
- Hemophilia refers to several hereditary bleeding disorders in which certain clotting factors are missing. A sex-linked disease causing a deficiency of factor VIII is the most common.

Diagnostic Blood Tests

A differential white blood cell count may indicate the kind of infection involved.

Prothrombin time assesses the amount of prothrombin present in the blood.

An SMAC (Sequential Multiple-channel Analyzer Computer) is a blood chemistry profile.

A Complete Blood Count (CBC) includes counts of all formed elements as well as hemoglobin and hematocrit.