Continuing Education Independent Study Series

The Blood

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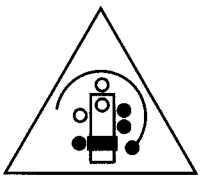

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PREFACE

"The Blood" is part of the AST Continuing Education Independent Study Series. The series has been specifically designed for surgical technologists to provide independent study opportunities that are relevant to the field and support the educational goals of the profession and the Association.

Acknowledgments

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INTRODUCTION

Purpose

The purpose of this module is to acquaint the learner with the components of blood and their functions. Upon completing this module, the learner will receive 2 continuing education (CE) credits in category 1G.

Objectives

Upon completing this module, the learner will be able to do the following:

1. Describe the function of blood.
2. Identify the formed elements of blood and their functions.
3. Identify the components of plasma and their functions.
4. Describe the blood clotting mechanism.
5. Identify the common blood groups.
6. Distinguish between blood typing and crossmatching.
7. Identify the normal blood lab values and the clinical implications of abnormal values.

Using the Module

1. Read the information provided, referring to the appropriate figures.
2. Complete the enclosed exam without referring back to the text. The questions are in a multiple-choice format. Select the best answer from the alternatives given.
3. Mail the completed exam to AST, CEIS Series, 7108-C S. Alton Way, Englewood, CO 80112-2106. Please keep a copy of your answers before mailing the exam. You must return the original copy of the answer sheet; this exam may not be copied and distributed to others.
4. Your exam will be graded, and you will be awarded continuing education credit upon achieving a minimum passing score of 70%. If you are an AST member, your credits will be automatically recorded and you do not need to submit the credits with your yearly CE report form.
5. You will be sent the correct answers to the exam. Compare your answers with the correct answers to evaluate your level of knowledge and determine what areas you need to review.

Studying Technical Material

To study technical material, find a quiet place where you can work uninterrupted. Sitting at a desk or work table will be most conducive to studying.

Having a medical dictionary available as you study is very helpful so you can look up any words with which you are unfamiliar. Make notes in the margins of any new definitions so that you can review them.

The ultimate test of how well you learn this material is your ability to relate your knowledge to what is happening in the surgical field. Apply your knowledge to the assessment of the patient's status during surgery.

Additional Resources

Core Curriculum for Surgical Technology, 3rd ed. Englewood, CO: Association of Surgical Technologists; 1990.

Davidson I, Henry J. *Clinical Diagnosis*. New York: WB Saunders; 1988.

Tortora G, Anagnostakos N. *Principles of Anatomy and Physiology*. 7th ed. New York: Harper & Row; 1993.

The Blood

The functions of blood are the following:

1. Transportation: Blood is responsible for the transportation of oxygen and carbon dioxide, nutrients, wastes, and hormones.
2. Regulation: Blood helps to regulate body temperature, pH, and water content within the body's cells.
3. Protection: Elements in the blood are responsible for clotting to prevent bleeding and destruction of microorganisms.

Histology

Blood consists of a liquid portion, plasma, and a formed portion, cells.

The formed elements, which represent 45% of the blood, consist of red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes).

Hemopoiesis is the process by which blood cells are produced. In the adult, hemopoiesis takes place in the red bone marrow or myeloid tissue. Some leukocytes are also produced in the lymphatic tissues of the spleen, tonsils, thymus gland, and lymph nodes.

Cells in the red bone marrow called hemocytoblasts develop into the different mature blood cells. The differentiation of the hemocytoblasts into five major precursor cells is represented in Figure 1.

Erythrocytes

Erythrocytes, or red blood cells, are biconcave disks without a nucleus. The cell membrane encloses the cytoplasm and hemoglobin, a red pigment molecule. Hemoglobin is responsible for the red color of blood and accounts for one third of the weight of the red blood cells.

Hemoglobin molecules consist of two pairs of polypeptide chains (referred to as globin) and four nonprotein pigments, hemes, which contain one atom of ferrous iron. The heme reversibly combines with molecules of oxygen or carbon dioxide.

The main function of hemoglobin is transporting oxygen in the form of oxyhemoglobin and transporting carbon dioxide in the form of carbaminohemoglobin throughout the body.

The normal life span of erythrocytes is about 120 days. The old cells are broken down by macrophages in the spleen, liver, and bone marrow. Hemoglobin is broken down into iron, which is stored and reused; bilirubin, which is secreted by the liver into bile; and globin, which is metabolized by the liver.

Erythropoiesis is the process of red blood formation. As indicated in Figure 1, the proerythroblasts go through a series of changes in the red bone marrow until they become immature red blood cells called reticulocytes. Within 1 to 2 days following their release from the red bone marrow, reticulocytes become erythrocytes.

Erythropoiesis is controlled by a triggering mechanism within specific kidney cells. A reduced oxygen supply resulting from reduced numbers of erythrocytes causes these cells to release an enzyme that converts a plasma protein into the hormone erythropoietin. Erythropoietin then stimulates the red bone marrow to produce more red blood cells.

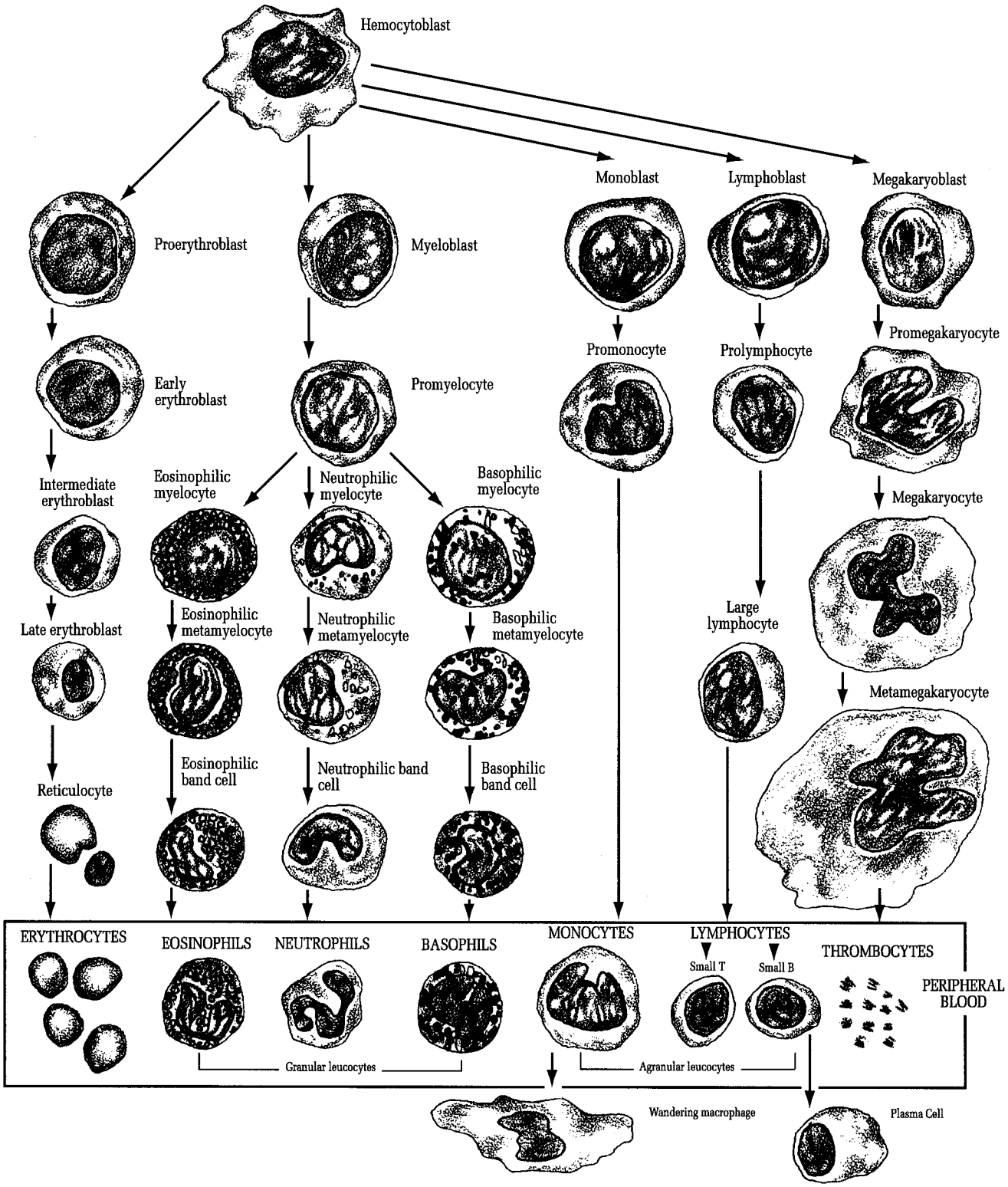

Figure 1.
Development of blood cells. (Adapted from Tortora et al.)

The inability of the erythrocyte to carry oxygen may be due to a number of causes, which include the following:

1. Iron deficiency: Insufficient iron for the production of hemoglobin.
2. Inadequate amino acids: Insufficient proteins for globin of hemoglobin.
3. Vitamin B12 deficiency: Vitamin B12 is necessary for normal production of erythrocytes in red bone marrow.
4. Intrinsic factor: Intrinsic factor is produced by the parietal cells of the stomach and is essential to the absorption of vitamin B12. Failure of the parietal cells to produce intrinsic factor results in pernicious anemia.
5. Hereditary defects: Thalassemia, which produces thin, fragile red blood cells, and sickle-cell anemia, which produces misshaped cells that rupture easily.

Leukocytes

Leukocytes or white blood cells, have a nucleus and they do not contain hemoglobin. Leukocytes are classified into two major groups: granular leukocytes and agranular leukocytes.

Granular leukocytes develop from myeloid tissues and have granules in their cytoplasm. Three types of cells originate as granular leukocytes: neutrophils, eosinophils, and basophils.

Agranular leukocytes develop from myeloid and lymphoid tissues and do not contain cytoplasmic granules. Lymphocytes and monocytes are agranular leukocytes.

Leukocytes have protein markers on the surface of their cells as do all other body cells. These proteins are referred to as human leukocyte associated antigens (HLA). HLA is unique for each person, determined by a single chromosome, and is used to identify or type tissue. Histocompatibility or tissue typing is used to match donor and recipient for organ transplantation and can be used to establish paternity in disputed parentage cases.

Each type of leukocyte functions in a different manner within the body. Neutrophils are primarily responsible for the destruction and ingestion of microorganisms and cellular debris. The number of neutrophils increases (neutrophilia) when the body experiences systemic infection. Other causes of neutrophilia include tissue destruction or necrosis, hemorrhage within a cavity, hemolysis, toxic overdose of drugs or chemicals, and physical or emotional stimuli such as muscle activity, pain, anger, heat, or cold.

An increase in the number of eosinophils is related to allergic diseases. It is thought that the antigen-antibody complexes or histamine may attract eosinophils chemotactically. In addition, eosinophilia is present if parasites such as tapeworms invade the body.

Basophils intensify the inflammatory response by liberating heparin, histamine, and serotonin in the tissues. Basophilia frequently occurs in allergic reactions, leukemia, polycythemia, and hemolytic anemia.

Lymphocytes are responsible for the development of antibodies. Whenever the body senses a foreign antigen (a cellular surface protein marker) in the body, lymphocytes will be chemically stimulated to produce antibodies that attach to the antigen and bind to it to render it harmless.

An increase in the number of monocytes is related to infection. Generally monocytes are slower to arrive at the site of infection but do so in larger quantities than other leukocytes. The monocytes will destroy the microbes and clean up the cellular debris. Monocytosis is usually a favorable sign in the recovery of an infection.

Platelets

Thrombocytes, or platelets, are the third formed element of blood. As indicated in Figure 1, thrombocytes develop from megakaryocytes. These megakaryocytes shed fragments of cytoplasm that are enclosed by pieces of cell membrane to form the platelet.

Platelets live for a short time, 8 to 11 days, in the vascular system. During that time, they are responsible for maintaining vascular integrity, plugging vascular injuries, and releasing platelet factors that promote the intrinsic clotting mechanism.

Plasma

Plasma is the straw-colored liquid portion of blood. Plasma itself is composed of water (91.5%) and various dissolved substances (8.5%).

The water in the blood comes from gastrointestinal tract absorption and from the body's cells.

The dissolved substances are primarily plasma proteins, nonprotein nitrogen substances (NPNs), products of digestion, enzymes, hormones, oxygen, carbon dioxide, and electrolytes.

The plasma proteins include albumins, which are responsible for blood viscosity and fluid balance; globulins, which provide antibodies; and fibrinogen, which provides for coagulation. In addition, within the plasma are chemicals known as coagulation factors that are essential for adequate clotting (Table 1).

Table 1. Plasma Coagulation Factors

I	Fibrinogen
II	Prothrombin
III	Thromboplastin
IV	Calcium
V	Proaccelerin
VII	Serum prothrombin conversion accelerator
VIII	Antihemophilic factor A
IX	Christmas factor, or antihemophilic factor B
X	Stuart and Power factor
XI	Antihemophilic factor C
XII	Hageman, glass, or contact factor
XIII	Fibrinase

Physiology of Blood Clotting

The clotting process is a very complex process that once initiated begins a cascade of events that result in the formation of a clot to stop bleeding.

Blood clotting may be initiated by either extrinsic sources (outside the blood) or intrinsic sources (within the blood). Whichever pathway the clotting takes, the coagulation factors will catalyze the activation of other factors until a clot is formed. Figure 2 illustrates these pathways.

In addition to the coagulation factors, the body needs calcium and vitamin K. Vitamin K is necessary for the synthesis of prothrombin and factors VII, IX, and X.

Extrinsic Pathway	Intrinsic Pathway
External Tissue Damage	Internal Endothelial Pathway
Coagulation Factor VII + Calcium Ions	Tissue Factor + Platelet Phosopholipids
Coagulation Factor X + Calcium Ions	Coagulation Factor VII + Calcium Ions + Phosopholipids
Coagulation Factor V	Coagulation Factor X + Calcium Ions + Coagulation Factor V

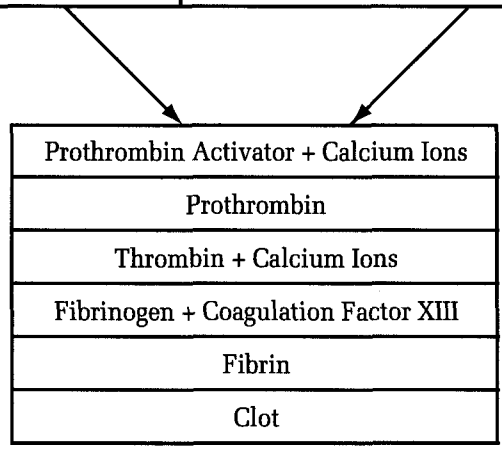

Figure 2.
The clotting cascade.

Blood Typing

The surface of the red blood cell contains genetically determined markers or antigens. These antigens are also known as agglutinogens or isoantigens. Presently, at least 300 different markers or groups have been identified. The oldest and most commonly known groups are the ABO group and the Rh group. Other groupings include the Lewis, Kell, Kidd, and Duffy systems.

These groupings are clinically significant when a patient has to be transfused with donor blood. The isoantigens of each blood group can cause the formation of isoantibodies or agglutinin in transfusion recipients. If a reaction occurs between the isoantigens of the donor and the isoantibodies of the recipient, the blood cells clump together (agglutinate) and then rupture (hemolysis). The amount of agglutination is related to the amount (titer) of isoantibodies in the blood.

Agglutination can block blood vessels causing a variety of problems from small rashes to kidney damage to brain damage to death. For this reason, incompatibilities between the isoantigens of donor blood and recipient blood are to be avoided.

ABO Groups

The ABO blood grouping involves two isoantigens symbolized by the letters A and B. If an individual has A isoantigens on the surface of his red blood cells, his blood is referred to as type A. If an individual has B isoantigens, her blood is type B. Some individuals have both A and B isoantigens on the surface of their red blood cells and therefore have type AB blood. If an individual does not have either A or B isoantigens, then his blood type is O. The distribution of the ABO system within the United States is shown in Table 2.

Table 2. Distribution of the ABO System

	White Population	Black Population
Type A	41%	27%
Type B	10%	20%
Type AB	4%	7%
Type O	45%	46%

Rh System

The second major blood classification system is the Rh system. Similar to the ABO system, the surface of the red blood cells either do (Rh positive) or do not (Rh negative) have the Rh isoantigen on their surface.

Blood Transfusions

When a blood transfusion becomes necessary, incompatibility must be avoided. Individuals must not receive blood with isoantigens different than their own.

Type A (A isoantigens) individuals can receive type A blood since they have type A isoantigens and type O blood. Type O has no isoantigens; therefore, the recipient's body can not react to any isoantigens. Type B individuals can receive type B blood and type O. Type AB individuals can receive type A or B or AB or type O since their blood normally contains the A and B isoantigens. The same logic applies to the Rh system.

Theoretically, this means that type O negative individuals are referred to as universal donors. Their blood can theoretically be given to all blood types as it does not contain any isoantigens. Individuals with type AB positive are referred to as universal recipients because their blood contains all the ABO and Rh isoantigens.

In addition to typing blood within the ABO and Rh systems, it is also necessary to crossmatch blood for transfusions. Crossmatching involves in vitro testing between the blood of the recipient and donor. This ensures the absence of incompatibility via isoantibodies/isoantigens of the major and minor blood groups or systems.

Diagnostic Blood Tests

Table 3 identifies the major preoperative diagnostic blood tests with normal values and clinical implications.

Table 3. Blood Lab Values

Lab Test	Normal Values	Use
Hemoglobin (Hgb)	12-15 g/100 ml (female) 14-16.5 g/100 ml (male)	Measures oxygen-carrying capacity of red blood cells. Used to determine anemia. Values decrease with anemia; increase with polycythemia.
Red blood count (RBC)	4.8 million/mm^3 (female) 5.4 million/mm^3 (male)	Measures actual number of cells. Determines lack of cells from blood loss or failure to produce new erythrocytes.
Hemocrit (Hct)	38%-46% (female) 40%-54% (male)	Measures the percentage of red blood cells in the blood. Determines decrease (anemia) or increase (polycythemia) in red blood cells.
Reticulocyte count	0.5%-1.5%	Measures the rate of erythropoiesis; used to evaluate red bone marrow function. Indicates a response to bleeding.
Erythrocyte (ESR) sedimentation rate	20 mm/hr (female) 15 mm/hr (male)	Used to screen for infections, inflammations, cancers. Values increase in pregnancy, infection, tissue destruction, and cancer.
Partial pressure of oxygen (PO_2)	105 mm Hg: arterial	Values increase in polycythemia and hyperventilation; decrease in anemia and hypoventilation.
Partial pressure of carbon dioxide (PCO_2)	40 mm Hg: arterial 45 mm Hg: venous	Values increase in hypoventilation, obstructive lung disease; decrease in hypoxia.
White blood count (WBC)	4,000 - 9,000/mm^3	Values increase during leucocytosis; decrease during leucopenia.

continued

Table 3. continued

Lab Test	Normal Values	Use
Differential white blood count		
Neutrophils	60%-70%	Acute bacterial infection.
Eosinophils	2%-4%	Allergic reaction and parasitic worms.
Basophils	0.5%-1%	Allergic reaction.
Lymphocytes	20%-25%	Antigen/antibody reaction.
Monocytes	3%-8%	Chronic infection. Used to determine probable cause of increased white blood cell count.
Platelet count	250,000-400,000/mm^3	Decrease may indicate bleeding problems (thrombocytopenia); increase may cause clotting problems.
Prothrombin time	11-15 seconds	Values increase in vitamin K and prothrombin deficiency causing prolonged bleeding.