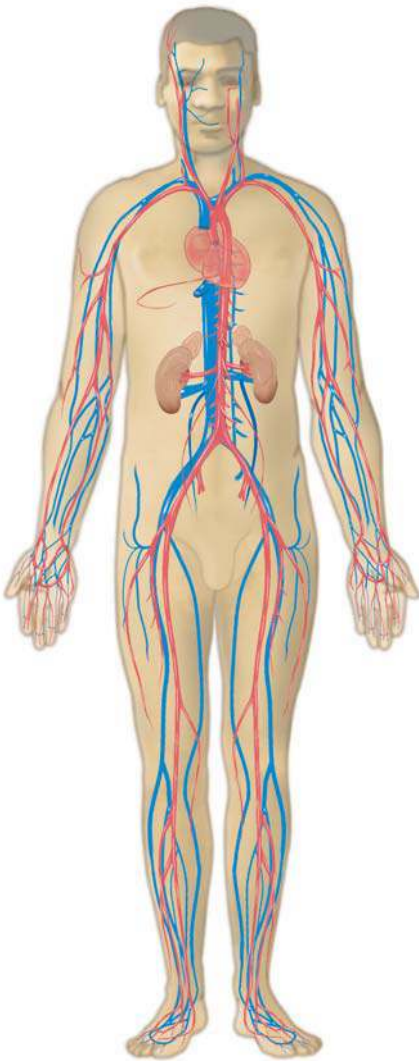


CHAPTER 12

The Blood System

► Hematology



After studying this chapter, you will be able to:

- 12.1** Name the parts of the blood system and discuss the function of each part
- 12.2** Define combining forms used in building words that relate to the blood system
- 12.3** Identify the meaning of related abbreviations
- 12.4** Name the common diagnoses, clinical procedures, and laboratory tests used in treating disorders of the blood system
- 12.5** List and define the major pathological conditions of the blood system
- 12.6** Explain the meaning of surgical terms related to the blood system
- 12.7** Recognize common pharmacological agents used in treating disorders of the blood system

Structure and Function

Blood is a complex mixture of cells, water, and various biochemical agents, such as proteins and sugars. It transports life-sustaining nutrients, oxygen, and hormones to all parts of the body. As a transport medium for waste products from cells of the body, it prevents toxic buildup. It helps maintain the stability of the fluid volume that exists within body tissues (a form of *homeostasis*, the maintaining of a balance), and it helps regulate body temperature. Without blood, human life is not possible. Figure 12-1a illustrates the blood system, with arteries shown in red and veins shown in blue. Figure 12-1b is a schematic showing the path of blood through the body.

An average adult has about 5 liters of blood circulating within the body. The volume of blood changes with body size, usually equaling about 8 percent of body weight. If a person loses blood, either through bleeding or by donating blood, most of the blood volume is replaced within 24 hours. If bleeding is extensive, blood transfusions may be necessary.

Blood is a thick liquid made up of a fluid part, **plasma**, and a solid part containing **red blood cells**, **white blood cells**, and **platelets**. Plasma (the liquid portion of unclotted blood) consists of water, proteins, salts, nutrients, vitamins, and hormones. If some proteins and blood cells are removed from plasma, as happens during coagulation (clotting), the resulting fluid is called **serum**. Serum is the liquid portion of clotted blood. *Serology* is the science that deals with the properties of serum, such as the presence of immunity-provoking agents.

To learn more about blood donation, go to the National Heart, Lung, and Blood Institute's Web site (www.nhlbi.nih.gov).

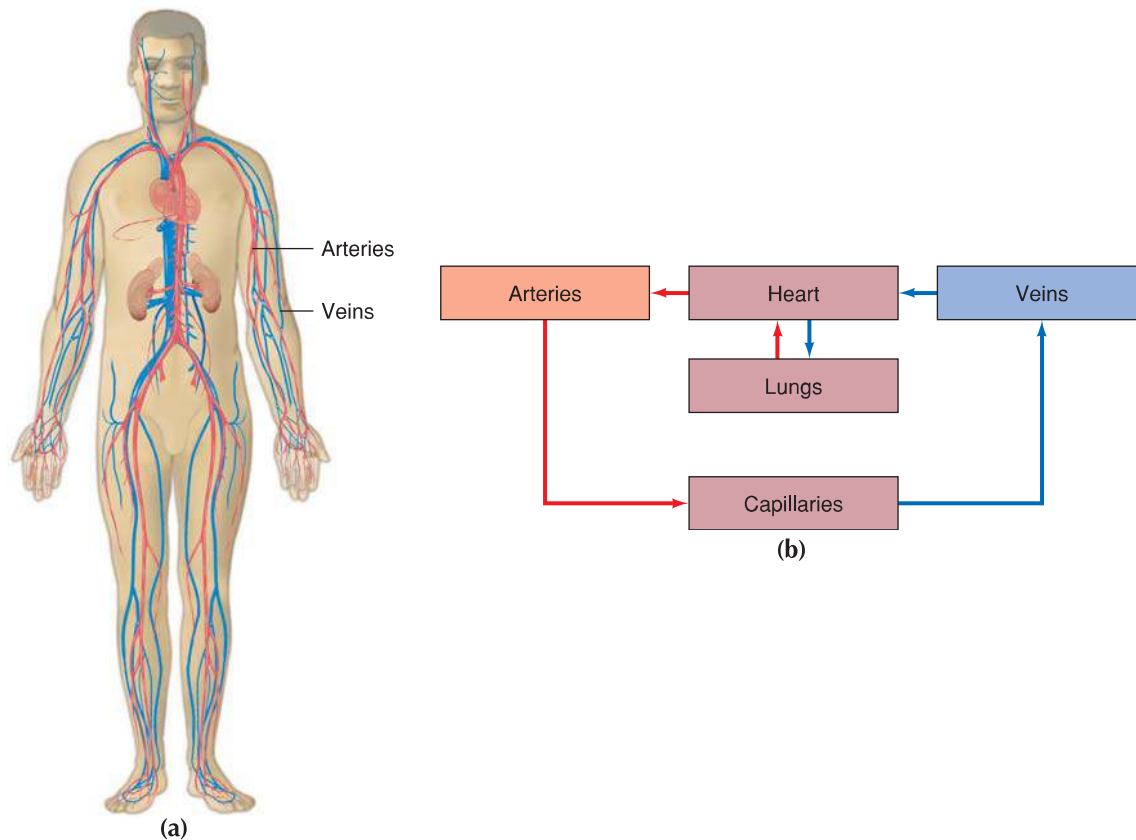


FIGURE 12-1 (a) The blood system transports life-sustaining nutrients to all parts of the body; (b) a schematic showing the path of blood through the body.

Plasma

When blood is separated, the plasma (about 55 percent of the blood) is the clear liquid made up of 92 percent water and 8 percent organic and inorganic chemicals. The 8 percent consists of proteins, nutrients, gases, electrolytes, and other substances.

The main groups of plasma proteins are **albumin**, **globulin**, **fibrinogen**, and **prothrombin**. Albumin helps regulate water movement between blood and tissue. Plasma proteins cannot pass through capillaries, and, in order to maintain a balance of fluids on both sides of the capillary walls, they create pressure that forces water into the bloodstream. Leakage of water out of the bloodstream can cause edema. An injury can upset the balance of water in the blood and, if too much water is lost, can eventually lead to shock.

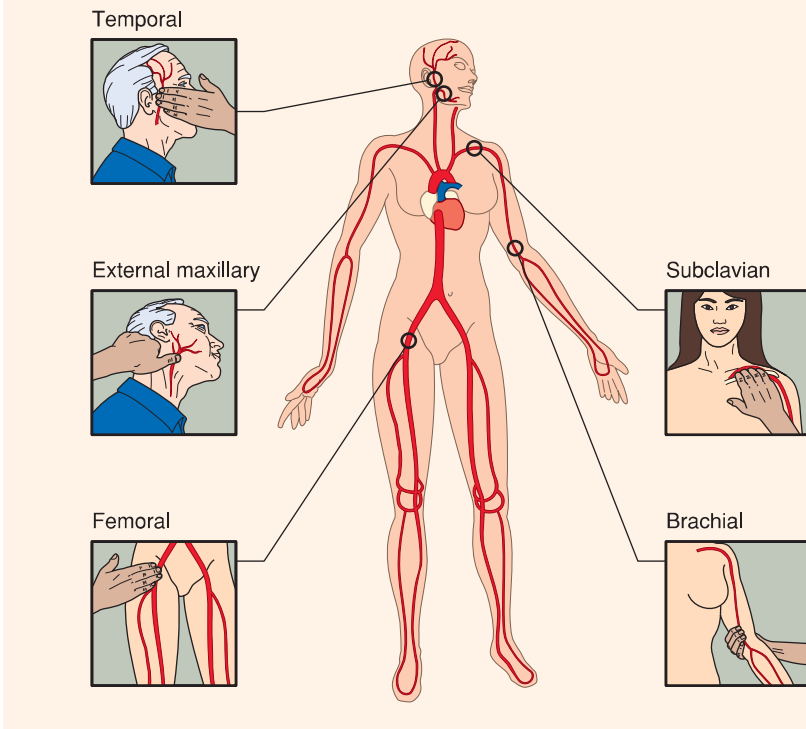
Globulins have different functions, depending on their type. The *alpha* and *beta* globulins, which are joined in the liver, transport lipids and fat-soluble vitamins. **Gamma globulins** arise in the lymphatic tissues and function as part of the immune system. Globulins can be separated from each other when plasma is placed in a special solution and electrical currents attract the different proteins to move in the direction of the electricity through a process called **electrophoresis**. Blood may also be *centrifuged*, put in a device that separates blood elements by spinning. **Plasmapheresis** is a process that uses centrifuging to take a patient's blood and return only red cells to that patient.

Fibrinogen and prothrombin are essential for blood **coagulation**, the process of **clotting**. The clot is formed by platelets that rush to the site of an

MORE ABOUT . . .

Blood

In an emergency situation, in which a person is hemorrhaging, a quick response can save a life. First, make sure the person can breathe. The most effective way to control hemorrhaging is to apply direct pressure on the wound, elevate the area (whenever possible, to a level above the heart), and apply pressure to the nearest pressure point. The points shown here are just some of the most common pressure points.



injury. They clump at the site and release a protein, **thromboplastin**, which combines with calcium and various clotting factors (I-V and VII-XIII) to form the **fibrin clot** (Figure 12-2). **Thrombin**, an enzyme, helps in formation of the clot. The clot tightens while releasing serum, a clear liquid. Blood clotting at the site of a wound is essential. Without it, one would bleed to death. Blood clotting inside blood vessels, however, can cause major cardiovascular problems. Some elements of the blood, such as **heparin**, prevent clots from forming during normal circulation.

Blood Cells

The solid part of the blood that is suspended in the plasma consists of the red blood cells (RBCs), also called **erythrocytes**, white blood cells (WBCs), also called **leukocytes**, and platelets, also referred to as **thrombocytes**. These cells or the solids in the blood make up about 45 percent of the blood. The measurement of the percentage of packed red blood cells is known as the **hematocrit**. Most blood cells are formed as **stem cells** (**hematocytoblasts**) or immature blood cells in the bone marrow. Stem cells mature in the bone marrow before entering the bloodstream and becoming *differentiated*, specialized in their purpose. Figure 12-3 shows the stages of

Stem cells can be gotten from umbilical cord blood. To find out about how to donate cord blood once a baby is born, go to the NIH website on stem cells (<http://stemcells.nih.gov>).

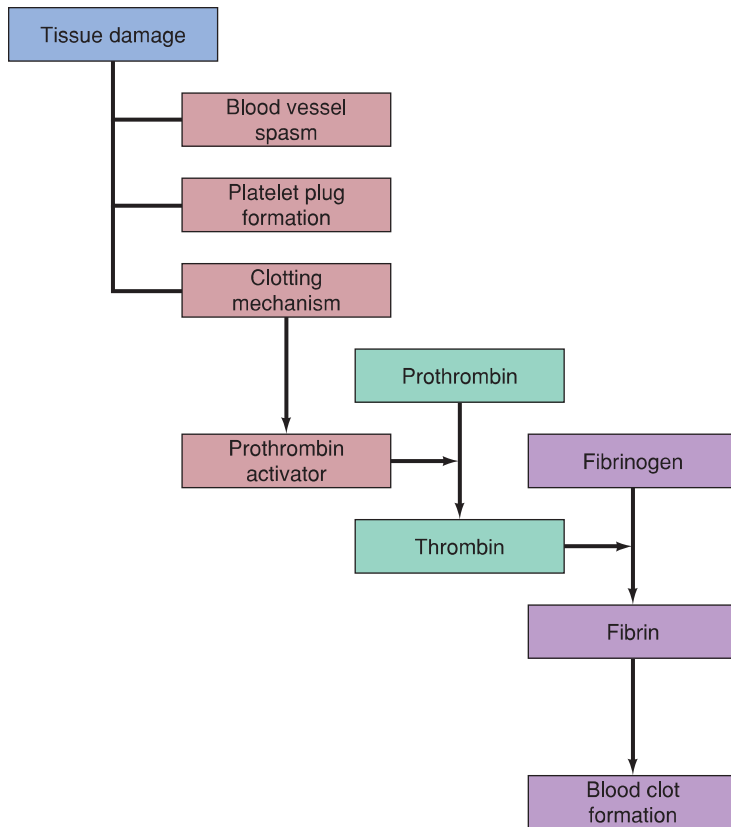


FIGURE 12-2 A fibrin clot is formed at the site of an injury.

blood cell development. The term *differential*, which you will see on written orders for blood tests, refers to the percentage of each type of white blood cell in the bloodstream.

MORE ABOUT . . .

Stem Cells

Stem cells are the foundation cells for all other cells in the body. As a new individual develops, the process of differentiation begins by designating certain cells to become specific cell types within the body. It is the stem cell's ability to be manipulated that is believed to hold the key to engineering new tissues to repair diseases or injuries. There are two types of stem cells that are at the center of this bioethical debate; embryonic and adult stem cells. Embryonic stem cells tend to be the preferred cell due to their genetic ability to easily divide and develop into all types of cells within the body. An adult stem cell found in a person or umbilical cord has a limited ability to form only certain types of cells.

Controversy about the use of embryonic stem cells arises because an embryo is used in the process. Some individuals who believe that human life begins at conception are strongly opposed to using embryos in research and development. Others counter that these cells are harvested for the purpose of reproduction by artificial means and unused embryos will be destroyed if not used. Why not use them for the benefit of those individuals whose disease processes could be treated or possibly cured?

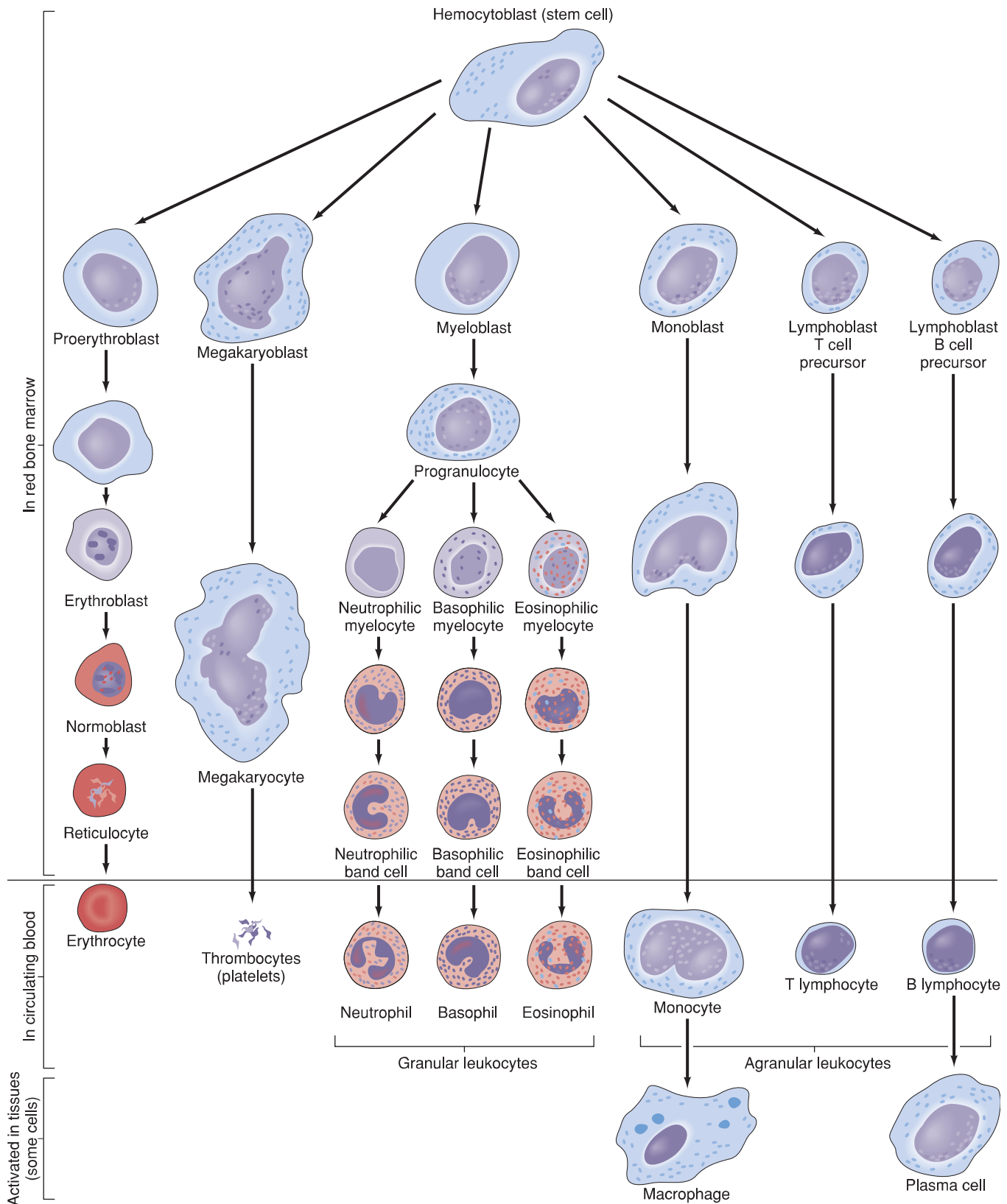


FIGURE 12-3 Development of blood cells from a hemocytoblast.

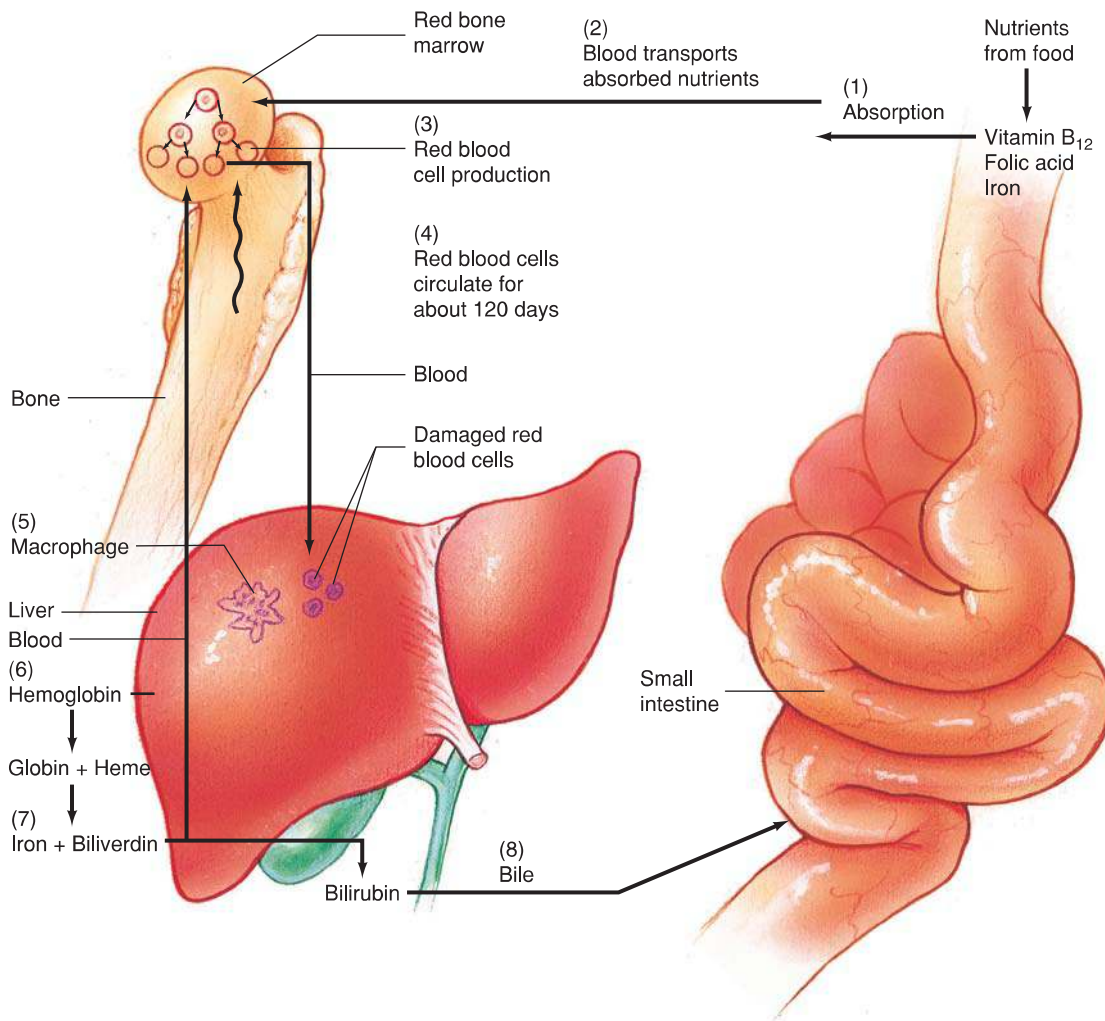


FIGURE 12-4 Life cycle of a red blood cell. Nutrients taken into the small intestine are then supplied to the bone marrow where red blood cells are produced. These cells then circulate in the body for approximately 120 days.

Erythrocytes or Red Blood Cells

A hormone produced in the kidneys, **erythropoietin**, stimulates the production of red blood cells in the bone marrow. When stem cells mature into erythrocytes, they lose their nucleus and become bi-concave.

A protein within red blood cells, **hemoglobin**, aids in the transport of oxygen to the cells of the body. Oxygen molecules have the ability to bond with hemoglobin molecules. When a red blood cell has oxygen on board, it becomes bright red in color. Oxygen-poor red blood cells are a deep burgundy color.

About one-third of each red blood cell is made up of hemoglobin. Hemoglobin is composed of **heme**, a pigment containing iron, and **globin**, a protein. Erythrocytes live for about 120 days. Some are removed from circulation each day to maintain a steady concentration of red blood cells. *Macrophages* are cells formed from stem cells that consume damaged or aged cells. The average number of red blood cells in a cubic millimeter of blood is 4.6 to 6.4 million for adult males and 4.2 to 5.4 million for adult females. This measurement is known as the **red blood cell count**. Figure 12-4 tracks the life cycle of a **red blood cell**.

Erythropoietin is used in the treatment of AIDS patients to encourage red blood cell production.

TABLE 12-1 Types of Leukocytes

Leukocytes	Percentage of Leukocytes in Blood	Function
granulocytes		
basophils	minimal—under 1 percent	release heparin and histamine
eosinophils	minimal—under 3 percent	kill parasites and help control inflammation
neutrophils	most plentiful—over 50 percent	remove unwanted particles
agranulocytes		
lymphocytes	plentiful—25 to 33 percent	important to immune system
monocytes	minimal—3 to 9 percent	destroy large unwanted particles

Leukocytes

Leukocytes or white blood cells protect against disease in various ways—for example, by destroying foreign substances. Leukocytes are transported in the bloodstream to the site of an infection. There are two main groups of leukocytes—granulocytes and agranulocytes.

The first group, **granulocytes**, have a granular cytoplasm and have nuclei with several lobes when viewed under a microscope and when stain is used. There are three types of granulocytes:

1. **Neutrophils** are the most plentiful leukocytes (over half of the white blood cells in the bloodstream). They do not stain distinctly with either an acidic or an alkaline dye. Their purpose is to remove small particles of unwanted material from the bloodstream.
2. **Eosinophils** are only about 1 to 3 percent of the leukocytes in the bloodstream. Their granules stain bright red in the presence of an acidic red dye called eosin. Their purpose is to kill parasites and to help control inflammations and allergic reactions.
3. **Basophils** are less than 1 percent of the leukocytes in the bloodstream. Their granules stain dark purple in the presence of alkaline dyes. They release heparin, an anticlotting factor, and **histamine**, a substance involved in allergic reactions.

The second group of leukocytes, **agranulocytes**, have cytoplasm with no granules. Their single nucleus does not have the dark-staining elements of granulocytes. There are two types of agranulocytes:

1. **Monocytes**, the largest blood cells, make up about 3 to 9 percent of the leukocytes in the bloodstream. They destroy large particles of unwanted material (such as old red blood cells) in the bloodstream.
2. **Lymphocytes** make up about 25 to 33 percent of the leukocytes in the bloodstream. They are essential to the immune system, discussed in Chapter 13.

Table 12-1 lists the types of white blood cells.

Platelets

Platelets or thrombocytes are fragments that break off from large cells in red bone marrow called **megakaryocytes**. Platelets live for about 10 days and

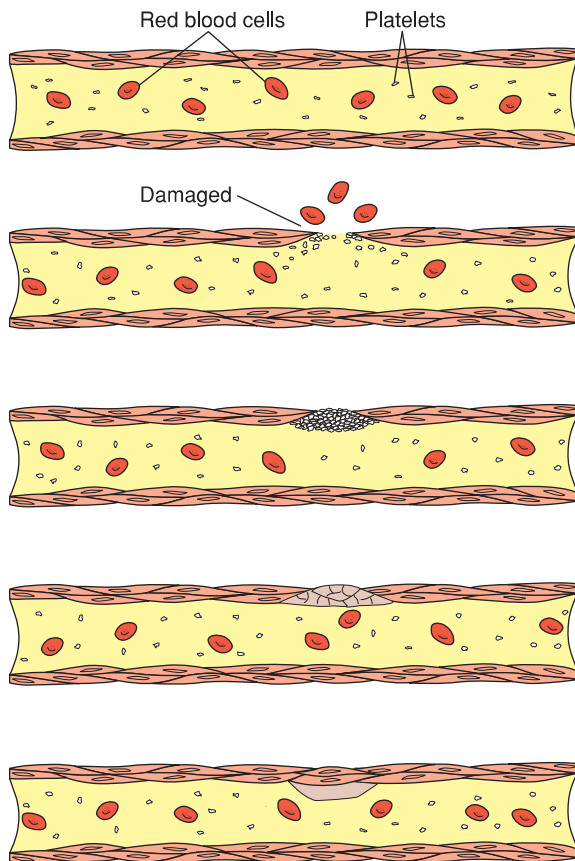


FIGURE 12-5 Platelets clumping together to form a clot.

Platelets begin to adhere to tissue edges and to each other as blood escapes.

They form a soft platelet plug.

Other clotting factors make this a stable plug or clot.

Tissue mends and anti-thrombin and other agents break down clot.

help in blood clotting. Platelets adhere to damaged tissue and to each other and group together to control blood loss from a blood vessel. Figure 12-5 shows platelets clumping together.

Blood Types

When blood is needed for **transfusion**, the blood being donated is tested for type and put into one of four human **blood types** or **groups**. The donated

MORE ABOUT . . .

Transfusions

Two early scientists attempted various experimental transfusions. Sir Christopher Wren (1632–1723), a famous English architect and scientist, did biological experiments in which he injected fluids into the veins of animals. This process is regarded as an early attempt at blood transfusions. During the same century, a French physician, Jean Baptiste Denis (1643–1704), tried unsuccessfully to transfuse sheep's blood into a human. Later, experiments with transfusing human blood succeeded somewhat, but the majority of people receiving transfusions died, until the advent of blood typing in the twentieth century. Once blood factors and typing became routine, transfusions were widely used in surgery. Later, it was found that some infections (hepatitis, AIDS) were transmitted by blood. Now, donated blood is carefully screened for infections.

TABLE 12-2 Blood Types

Blood Type	Antigen	Antibody	Percent of Population with This Type
A	A	Anti-B	41
B	B	Anti-A	10
AB	A and B	Neither anti-A nor anti-B	4
O	Neither A nor B	Both anti-A and anti-B	45

The lives of some animals are saved by blood transfusions. Go to www.cvm.uiuc.edu/petcolumns/showarticle.cfm?id=114 and search the term “transfusions” read about the similarities between human and some pet transfusions.

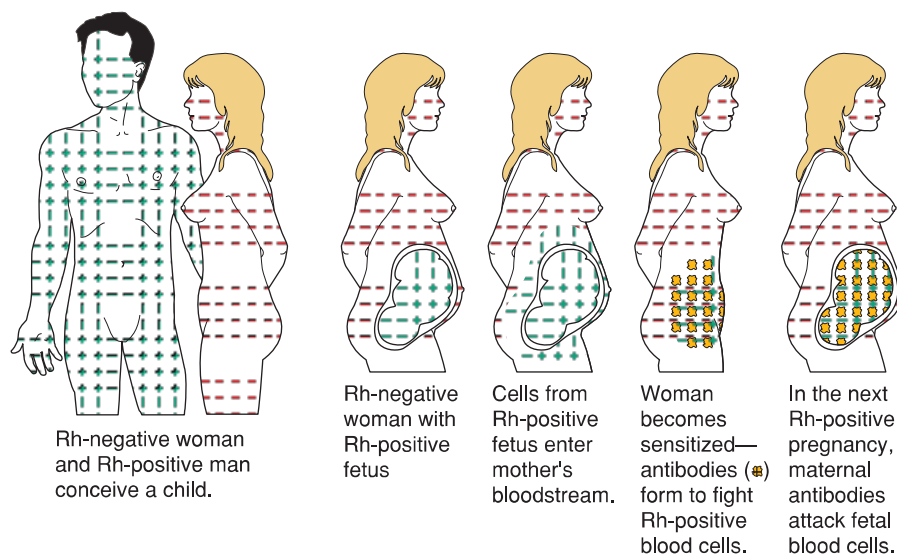
blood must be tested since an incompatible blood type from a donor can cause adverse reactions. Blood typing is based on the antigens (substances that promote an immune response) and antibodies (special proteins in the blood) present in the blood. (Chapter 13 describes the work of antigens and antibodies in the immune system.) The most common type of blood in the population is O, followed by A, B, and AB in descending order. Table 12-2 lists the four blood types and their characteristics.

The danger in transfusing blood of a different type is that **agglutination** or clumping of the antigens stops the flow of blood, which can be fatal. People with type O blood have no antigens, so people with type O can donate to all other types and are, therefore, called *universal donors*. People with AB blood are called *universal recipients* because they can receive blood from people with all the other types and not experience clotting.

In addition to the four human blood types, there is a positive or negative element in the blood. **Rh factor** is a type of antigen first identified in rhesus monkeys. **Rh-positive** blood contains this factor and **Rh-negative** blood does not. The factor contains any of more than 30 types of **agglutinogens**, substances that cause agglutination, and can be fatal to anyone who receives blood with a factor different from the donor.

Rh factor is particularly important during pregnancy. The fetus of parents with different Rh factors could be harmed by a fatal disease or a type of anemia if preventive measures are not taken prior to birth. The problem arises

FIGURE 12-6 How the Rh factor affects pregnancy.



when the mother is Rh-negative and produces antibodies to the father's Rh-positive factor present in the fetus. When the Rh-negative mother becomes exposed to the Rh-positive blood, usually during childbirth, antibodies are formed by the mother. The problem does not arise during a first pregnancy but will arise in each subsequent pregnancy because the antibodies that arise after the first birth would carry a risk for an Rh-positive fetus. Treatment with Rho-gam, a gamma globulin, during each pregnancy usually prevents the problem. Figure 12-6 shows how a combination of Rh factors affects pregnancy.

VOCABULARY REVIEW

In the previous section, you learned terms relating to the blood system. Before going on to the exercises, review the terms below and refer to the previous section if you have any questions. Pronunciations are provided for certain terms. Sometimes information about where the word came from is included after the term. These etymologies (word histories) are for your information only. You do not need to memorize them.

Term	Definition
agglutination [ă-glŭ-tĭ-NĀ-shŭn] gluten, glue	Clumping of cells and particles in blood.
agglutinin [ă-glŭ-TĪN-ō-jĕn]	Substance that causes agglutination.
agranulocyte [ā-GRĀN-yŭ-lō-sĭt]	Leukocyte with nongranular cytoplasm.
albumin [ăl-BYŪ-mĭn] Latin <i>albumen</i> , egg white	Simple protein found in plasma.
basophil [BĀ-sō-fĭl] baso-, base + -phil, attraction	Leukocyte containing heparin and histamine.
blood [blŭd] Old English <i>blod</i>	Fluid (containing plasma, red blood cells, white blood cells, and platelets) circulated throughout the arteries, veins, capillaries, and heart.
blood types or groups	Classification of blood according to its antigen and antibody qualities.
coagulation [kō-ăg-yŭ-LĀ-shŭn]	Changing of a liquid, especially blood, into a semi-solid.
electrophoresis [ē-lĕk-trō-FŌR-ē-sĭs] electro-, electricity + phoresis, carrying	Process of separating particles in a solution by passing electricity through the liquid.
eosinophil [ē-ō-SĪN-ō-fĭl] eosino-, fluorescent dye + -phil	Type of granulocyte.
erythrocyte [ĕ-RĪTH-rō-sĭt] erythro-, red + -cyte (blood) cell	Mature red blood cell.
erythropoietin [ĕ-rĭth-rō-PŌY-ĕ-tĭn] erythro(cyte) + -poiesis, making	Hormone released by the kidneys to stimulate red blood cell production.
fibrin [FĪ-brĭn] clot	Clot-forming threads formed at the site of an injury during coagulation where platelets clump together with various other substances.
fibrinogen [fĭ-BRĪN-ō-jĕn] fibrino-, fibrin + -gen, producing	Protein in plasma that aids in clotting.

Term	Definition
gamma globulin [GÄ-mă GLÖB-yū-lĭn]	Globulin that arises in lymphatic tissue and functions as part of the immune system.
globin [GLÖ-bĭn] From Latin <i>globus</i> , ball	Protein molecule in the blood, a part of hemoglobin.
globulin [GLÖB-yū-lĭn] From Latin <i>globulus</i> , globule	Any of a family of proteins in blood plasma.
granulocyte [GRÄN-yū-lō-sĭt] Latin <i>granulum</i> , granule + -cyte	Leukocyte with granular cytoplasm.
hematocrit [HĒ-mă-tō-krit, HĒM-ă-tō-krit] hemato- + Greek <i>krino</i> , to separate	Measure of the percentage of red blood cells in a blood sample.
hematocytoblast [HĒ-mă-tō-SĪ-tō-blăst] hemato-, blood + -cyto- cell + -blast, immature cell	Most immature blood cell.
heme [hēm] Greek <i>haima</i> , blood	Pigment containing iron in hemoglobin.
hemoglobin [hē-mō-GLÖ-bĭn] hemo-, blood + glob(ul)in	Protein in red blood cells essential to the transport of oxygen.
heparin [HĒP-ă-rĭn] From Greek <i>hepar</i> , liver	Substance in blood that prevents clotting.
histamine [HĪS-tă-mĕn]	Substance released by basophils and eosinophils; involved in allergic reactions.
leukocyte [LŪ-kō-sĭt] leuko-, white + -cyte	Mature white blood cell.
lymphocyte [LĪM-fō-sĭt] lympho-, lymph + -cyte	Type of agranulocyte.
megakaryocyte [mĕg-ă-KĀR-ē-ō-sĭt] mega-, large + karyo-, nucleus + -cyte	Large cells in red bone marrow that form platelets.
monocyte [MÖN-ō-sĭt] mono-, one + -cyte	Type of agranulocyte.
neutrophil [NŪ-trō-fĭl] neutro-, neutral + -phil	Type of leukocyte; granulocyte.
plasma [PLĂZ-mă] Greek	Liquid portion of unclotted blood.
plasmapheresis [PLĂZ-mă-fĕ-RĒ-sĭs] plasma + -pheresis, removal	Process of removing blood from a person, centrifuging it, and returning only red blood cells to that person.
platelet [PLĀT-lĕt] plate + -let, small	Thrombocyte; part of a megakaryocyte that initiates clotting.
prothrombin [prō-THRÖM-bĭn]	Type of plasma protein that aids in clotting.
red blood cell	One of the solid parts of blood formed from stem cells and having hemoglobin within; erythrocyte.
red blood cell count	Measurement of red blood cells in a cubic millimeter of blood.
Rh factor rh(esus monkey)	Type of antigen in blood that can cause a transfusion reaction.
Rh-negative	Lacking Rh factor on surface of blood cells.
Rh-positive	Having Rh factor on surface of blood cells.

Term	Definition
serum [SĒR-ŭm] Latin, whey	The liquid left after blood has clotted.
stem cell	Immature cell formed in bone marrow that becomes differentiated into either a red or a white blood cell.
thrombin [THRŌMB-ĭn]	Enzyme that helps in clot formation.
thrombocyte [THRŌM-bō-sīt] thrombo-, blood clot + -cyte	Platelet; cell fragment that produces thrombin.
thromboplastin [thrŏm-bō-PLĀS-tĭn] thrombo- + Greek <i>plastos</i> , formed	Protein that aids in forming a fibrin clot.
transfusion [trăns-FYŪ-zhŭn] From Latin <i>transfundo</i> , to pour from one vessel to another	Injection of donor blood into a person needing blood.
white blood cell	One of the solid parts of blood from stem cells that plays a role in defense against disease; leukocyte.

STRUCTURE AND FUNCTION EXERCISES

Check Your Knowledge

After each of the following, write the letter of the component of blood that is most closely related to either a, b, or c.

a. red blood cell b. white blood cell c. component of plasma

- | | |
|-------------------------|--------------------------|
| 1. albumin _____ | 8. beta globulin _____ |
| 2. hemoglobin _____ | 9. monocyte _____ |
| 3. leukocyte _____ | 10. neutrophils _____ |
| 4. eosinophils _____ | 11. histamine _____ |
| 5. gamma globulin _____ | 12. alpha globulin _____ |
| 6. fibrinogen _____ | 13. lymphocytes _____ |
| 7. basophils _____ | |

Find the Type

Write the correct blood type, A, B, AB, or O, in the space following each phrase.

- | | |
|---|--|
| 14. Has A and B antigens _____ | 19. Has neither anti-A nor anti-B antibodies _____ |
| 15. Has neither A nor B antigens _____ | 20. Has only anti-A antibodies _____ |
| 16. Has only B antigens _____ | 21. Has only anti-B antibodies _____ |
| 17. Has only A antigens _____ | |
| 18. Has both anti-A and anti-B antibodies _____ | |

Find a Match

Match the term in the left column with its correct definition in the right column.

- | | |
|----------------------|----------------------|
| 22. ____ coagulation | a. type of leukocyte |
|----------------------|----------------------|

23. ____ heparin
24. ____ neutrophil
25. ____ albumin
26. ____ agglutination
27. ____ Rh factor
28. ____ erythrocyte
29. ____ platelet
- b. a blood protein
- c. clumping of incompatible blood cells
- d. process of clotting
- e. antigen
- f. cell that activates clotting
- g. an anticoagulant
- h. red blood cell

CASE STUDY

Getting Treatment

John Maynard was admitted to the hospital on April 2, 2XXX, complaining of respiratory problems and left-sided lower abdominal pain. The doctor on call ordered blood tests, and Mr. Maynard was found to be anemic. Because of Mr. Maynard's multiple medical problems,

a hematologist was called in to consult about the disease and treatment of this patient. The history as written in his medical record is as follows:

HISTORY OF PRESENT ILLNESS: John Maynard is an 83-year-old man who was admitted on April 2, 2XXX, with acute exacerbation of chronic obstructive pulmonary disease and left-sided lower abdominal pain. He has been admitted in the past with a similar kind of pain but on the right side. He was evaluated by Dr. Evans in the past, but no obvious additional problem was identified. During this present admission, he was also found to be anemic.

On direct interviewing: Mr. Maynard denies any acute blood loss. His stool and urine color are normal. He has a history of a stroke and has not been ambulatory. He lives with his nephew, who takes care of him. He denies any night sweats. He did not notice any new lumps or bruising anywhere. No new bone pain. He feels short of breath with minimal activity. He denies any chest pain or palpitations. He feels dizzy at times.

Critical Thinking

30. Blood tests can reveal problems almost anywhere in the body. Why are the elements in blood a good measure of many bodily functions?

31. Does Mr. Maynard's blood type (O positive) make him more susceptible to illnesses? Why or why not?

Combining Forms and Abbreviations

The lists below include combining forms and abbreviations that relate specifically to the blood system. Pronunciations are provided for the examples.

COMBINING FORM	MEANING	EXAMPLE
agglutin(o)	agglutinin	agglutinogenic [ă-GLŪ-tĭn-ō-JĔN-ĭk], causing the production of agglutinin
eosino	eosinophil	eosinopenia [Ē-ō-sĭn-ō-PĒ-nē-ă], abnormally low count of eosinophils

COMBINING FORM	MEANING	EXAMPLE
erythr(o)	red	<i>erythrocyte</i> [ĕ-RĬTH-rō-sīt], red blood cell
hemo, hemat(o)	blood	<i>hemodialysis</i> [HĒ-mō-dī-ĀL-ĭ-sĭs], external dialysis performed by separating solid substances and water from the blood
leuk(o)	white	<i>leukoblast</i> [LŪ-kō-blăst], immature white blood cell
phag(o)	eating, devouring	<i>phagocyte</i> [FĀG-ō-sīt], cell that consumes other substances, such as bacteria
thromb(o)	blood clot	<i>thrombocyte</i> [THRŌM-bō-sīt], cell involved in blood clotting

ABBREVIATION	MEANING	ABBREVIATION	MEANING
APTT	activated partial thromboplastin time	MCHC	mean corpuscular hemoglobin concentration
baso	basophil	MCV	mean corpuscular volume
BCP	biochemistry panel	mono	monocyte
BMT	bone marrow transplant	PCV	packed cell volume
CBC	complete blood count	PLT	platelet count
diff	differential blood count	PMN, poly	polymorphonuclear neutrophil
eos	eosinophils	PT	prothrombin time
ESR	erythrocyte sedimentation rate	PTT	partial thromboplastin time
G-CSF	granulocyte colony-stimulating factor	RBC	red blood cell count
GM-CSF	granulocyte macrophage colony-stimulating factor	SR, sed. rate	sedimentation rate
HCT, Hct	hematocrit	seg	segmented mature white blood cells
HGB, Hgb, HB	hemoglobin	WBC	white blood cell count
MCH	mean corpuscular hemoglobin		

COMBINING FORMS AND ABBREVIATIONS EXERCISES

Find a Match

Match the terms on the left that contain blood system combining forms with the correct definition on the right. You will be using the combining forms, suffixes, or prefixes you have learned in this chapter and in Chapters 1, 2, and 3.

- | | |
|-------------------------|--|
| 32. ____ leukocytolysis | a. development of white blood cells |
| 33. ____ hemotoxin | b. instrument for counting red blood cells |
| 34. ____ thrombogenic | c. destruction of a clot |

35. ____ hemostasis
36. ____ eosinopenia
37. ____ erythrocytometer
38. ____ hemanalysis
39. ____ thrombolysis
40. ____ erythralgia
41. ____ leukopoiesis
- d. painful skin redness
- e. destruction of white blood cells
- f. substance that causes blood poisoning
- g. causing blood coagulation
- h. stoppage of bleeding
- i. blood analysis
- j. low number of eosinophils

Build Your Medical Vocabulary

Define the following words using the list of blood system combining forms above and the prefixes, suffixes, and combining forms in Chapters 1, 2, and 3.

42. agglutinophilic
43. thrombectomy
44. erythroblast
45. hematopathology
46. eosinotaxis
47. lymphoblast
48. phagosome
49. polycythemia
50. cytology
51. leukocyte
52. leukemia
53. thrombocytopenia
54. hematoma
55. erythrocytosis

CASE STUDY

Interpreting Results

The laboratory data on Mr. Maynard's record is as follows.

April 2, 2XXX: PSA 1.8
 April 2, 2XXX: BUN 6, creatinine .7, calcium 8.3, uric acid 8.7, SGOT 42, SGPT 38, alkaline phosphatase 86, total bilirubin 0.7.
 April 2, 2XXX: White blood cell count 5.8, hemoglobin 10.4, HCT 31.1, platelet count 275,000.
 December 4, 2XXX: vitamin B12 1,230, folate 16.1.
 December 6, 2XXX: HCT 38.9.
 December 10, 2XXX: HCT 32.3.

Critical Thinking

56. What procedure is used to obtain the blood samples needed in Mr. Maynard's case? Is it safe to take several blood samples at once? Why or why not?
57. What is the difference between an RBC and a WBC?

Diagnostic, Procedural, and Laboratory Terms

Phlebotomy or **venipuncture**, the withdrawal of blood for examination, is probably the most frequently used diagnostic tool in medicine (Figure 12-7). Various measurements provide a clue as to someone's general health and aid in diagnosing specific conditions. Table 12-3 lists common blood analyses, and Figure 12-8 shows laboratory results for specific blood tests.

Elyse Armadian, M.D. 3 South Windsor Street Fairfield, MN 00219 300-546-7890		Laboratory Report Sunview Diagnostics 6712 Adams Drive Fairfield, MN 00220 300-546-7000	
Patient: Janine Josephs Date Collected: 09/30/XXXX Date Received: 09/30/XXXX		Patient ID: 099-00-1200 Time Collected: 16:05 Date Reported: 10/06/XXXX	Date of Birth: 08/07/43 Total Volume: 2000
Test	Result	Flag	Reference
<i>Complete Blood Count</i>			
WBC	4.0		3.9-11.1
RBC	4.11		3.80-5.20
HCT	39.7		34.0-47.0
MCV	96.5		80.0-98.0
MCH	32.9		27.1-34.0
MCHC	34.0		32.0-36.0
MPV	8.6		7.5-11.5
NEUTROPHILS %	45.6		38.0-80.0
NEUTROPHILS ABS.	1.82		1.70-8.50
LYMPHOCYTES %	36.1		15.0-49.0
LYMPHOCYTES ABS.	1.44		1.00-3.50
EOSINOPHILS %	4.5		0.0-8.0
EOSINOPHILS ABS.	0.18		0.03-0.55
BASOPHILS %	0.7		0.0-2.0
BASOPHILS ABS.	0.03		0.000-0.185
PLATELET COUNT	229		150-400
<i>Automated Chemistries</i>			
GLUCOSE	80		65-109
UREA NITROGEN	17		6-30
CREATININE (SERUM)	0.6		0.5-1.3
UREA NITROGEN/CREATININE	28		10-29
SODIUM	140		135-145
POTASSIUM	4.4		3.5-5.3
CHLORIDE	106		96-109
CO ₂	28		20-31
ANION GAP	6		3-19
CALCIUM	9.8		8.6-10.4
PHOSPHORUS	3.6		2.2-4.6
AST (SGOT)	28		0-30
ALT (SGPT)	19		0-34
BILIRUBIN, TOTAL	0.5		0.2-1.2
PROTEIN, TOTAL	7.8		6.2-8.2
ALBUMIN	4.3		3.5-5.0
GLOBULIN	3.5		2.1-3.8
URIC ACID	2.4		2.0-7.5
CHOLESTEROL	232	*	120-199
TRIGLYCERIDES	68		40-199
IRON	85		30-150
HDL CHOLESTEROL	73	*	35-59
CHOLESTEROL/HDL RATIO	3.2		3.2-5.7
LDL, CALCULATED	148	*	70-129
T3, UPTAKE	32		24-37
T4, TOTAL	6.9		4.5-12.8

FIGURE 12-8 A laboratory report showing a number of tests and the expected range of results for each type of test.

Most of the blood tests described in Table 12-3 are performed in a laboratory. Names of tests may vary according to the region of the country or the practice of a particular doctor. For example, a biochemistry panel is sometimes called a **chemistry profile**, and a blood chemistry is sometimes

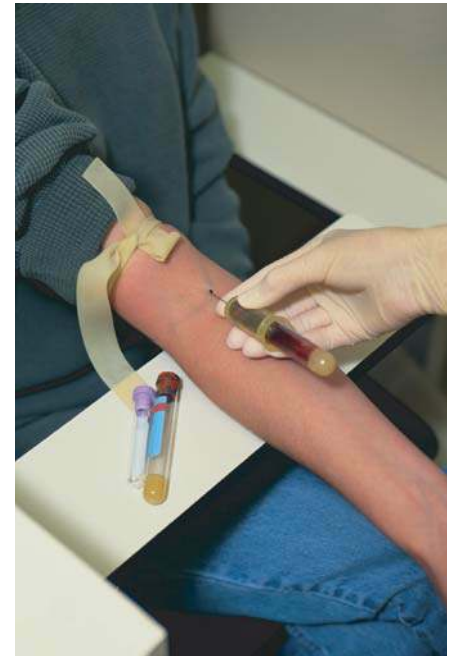


FIGURE 12-7 Venipuncture is used in most regular medical examinations to extract blood for analysis.

TABLE 12-3 Common Blood Analyses (see Appendix D for Normal Laboratory Values)

Test or Procedure	Purpose of Test	Common Diseases/Disorders That May Be Indicated
complete blood count (CBC)	common screen for basic medical checkup (Figure 12-8)	iron-deficiency anemia bacterial or viral infection internal bleeding dehydration aplastic anemia impaired renal function liver disease circulatory disorder
blood chemistry	test of plasma for presence of most substances, such as glucose, cholesterol, uric acid, and electrolytes	diabetes hyperlipidemia gout circulatory disorders impaired renal function liver diseases general metabolic disorder
biochemistry panel	group of automated tests for various common diseases or disorders	same as blood chemistry
blood indices	measurement of size, volume, and content of red blood cells	classification of anemias
blood culture	test of a blood specimen in a culture in which microorganisms are observed; test for infections	septicemia bacterial infections
erythrocyte sedimentation rate (ESR); sedimentation rate (SR)	test for rate at which red blood cells fall through plasma; indicator of inflammation and/or tissue injury	infections joint inflammation sickle cell anemia liver and kidney disorders
white blood cell differential and red blood cell morphology	test for number of types of leukocytes and shape of red blood cells	infection anemia leukemia poikilocytosis anisocytosis
platelet count (PLT)	test for number of thrombocytes in a blood sample	hemorrhage infections malignancy hypersplenism aplastic anemia thrombocytopenia
partial thromboplastin time (PTT)	test for coagulation defects	vitamin K deficiency hepatic disease hemophilia hemorrhagic disorders
prothrombin time (PT)	test for coagulation defects	vitamin K deficiency hepatic disease hemorrhagic disorders hemophilia

TABLE 12-3 Common Blood Analyses (see Appendix D for Normal Laboratory Values) (cont.)

Test or Procedure	Purpose of Test	Common Diseases/Disorders That May Be Indicated
antiglobulin test; <i>Coombs' test</i>	test for antibodies on red blood cells	Rh factor and anemia
white blood count (WBC)	number of white blood cells in a sample (usually done as part of complete blood count)	bacterial or viral infection aplastic anemia leukemia leukocytosis
red blood count (RBC)	number of red blood cells in a sample (usually done as part of complete blood count)	polycythemia dehydration iron-deficiency anemia blood loss erythropoiesis
hemoglobin (HGB, Hgb)	level of hemoglobin in blood (usually done as part of complete blood count)	polycythemia dehydration anemia sickle cell anemia recent hemorrhage
hematocrit (HCT, Hct)	measure of packed red blood cells in a sample (usually done as part of complete blood count). This shows the percent of red blood cells.	polycythemia dehydration blood loss anemia
mean corpuscular volume (MCV)	volume of individual cells (usually part of blood indices)	microcytic or macrocytic anemia
mean corpuscular hemoglobin (MCH)	weight of hemoglobin in average red blood cell (usually part of blood indices)	classification of anemia
mean corpuscular hemoglobin concentration (MCHC)	concentration of hemoglobin in a red blood cell (usually part of blood indices)	hyperchromic or hypochromic anemia

known as an **SMA (sequential multiple analyzer)**, the name of the first machine used to analyze blood chemistries.

VOCABULARY REVIEW

In the previous section, you learned diagnostic, procedural, and laboratory terms. Before going on to the exercises, review the terms below and refer to the previous section if you have any questions. Pronunciations are provided for certain terms. Sometimes information about where the word came from is included after the term. These etymologies (word histories) are for your information only. You do not need to memorize them.

Term	Definition
antiglobulin [ĂN-tē-GLŎB-yū-lĭn] test anti(body) + globulin	Test for antibodies on red blood cells.
biochemistry panel	Common group of automated tests run on one blood sample.

Term	Definition
blood chemistry	Test of plasma for presence of a particular substance such as glucose.
blood culture	Test of a blood specimen in a culture medium to observe for particular microorganisms.
blood indices [ĬN-dĭ-sēz]	Measurement of the characteristics of red blood cells.
chemistry profile	See blood chemistry.
complete blood count (CBC)	Most common blood test for a number of factors.
erythrocyte sedimentation rate (ESR)	Test for rate at which red blood cells fall through plasma.
partial thromboplastin time (PTT)	Test for ability of blood to coagulate.
phlebotomy [flĕ-BŎT-ō-mē] phlebo-, vein + -tomy, a cutting	See venipuncture.
platelet count (PLT)	Measurement of number of platelets in a blood sample.
prothrombin time (PT)	Test for ability of blood to coagulate.
red blood cell morphology	Observation of shape of red blood cells.
sedimentation rate (SR)	See erythrocyte sedimentation rate.
SMA (sequential multiple analyzer)	Original blood chemistry machine; now a synonym for blood chemistry.
venipuncture [VĔN-ĭ-pŭnk-chŭr, VĔ-nĭ-pŭnk-chŭr] veni-, vein + puncture	Insertion of a needle into a vein, usually for the purpose of extracting a blood sample.

CASE STUDY

Evaluating the Tests

Mr. Maynard's record has the following notes from the hematologist's evaluation.

ASSESSMENT: Mr. Maynard has multiple medical problems. He has recently been admitted with abdominal discomfort, the etiology of which is unclear at this point. He was also found to have anemia. A review of his laboratory data shows that his hematocrit has been fluctuating between 27 and 38. His hematocrit on December 6 was 38.9, but within four days it dropped

to 32.3. Since then there have also been several incidences in which his hematocrit dropped further, but then improved. This variation in the hematocrit is suggestive of some ongoing blood loss.

Critical Thinking

58. Other than blood loss, name at least two other conditions the HCT results might indicate.
59. What is the name of a test for leukocytes?

DIAGNOSTIC, PROCEDURAL, AND LABORATORY TERMS EXERCISES

Match the Test

Match the name of the test in the column on the left to its correct description in the column on the right.

- | | |
|--|---|
| 60. ____ blood culture | a. average red blood cell volume |
| 61. ____ hematocrit | b. antibodies on red blood cells |
| 62. ____ sedimentation rate | c. rate at which red blood cells fall |
| 63. ____ white blood count | d. group of automated tests |
| 64. ____ antiglobulin test | e. most common blood test |
| 65. ____ mean corpuscular hemoglobin concentration | f. clotting factors test |
| 66. ____ mean corpuscular volume | g. number of white blood cells |
| 67. ____ complete blood count | h. measure of packed red blood cells |
| 68. ____ prothrombin time | i. concentration of hemoglobin in red blood cells |
| 69. ____ biochemistry panel | j. growing of microorganisms in a culture |

Find the Value

Give the expected (normal) range for each of the following laboratory measurements.

- | | |
|------------------------|----------------|
| 70. cholesterol _____ | 75. PLT _____ |
| 71. sodium _____ | 76. HCT _____ |
| 72. iron _____ | 77. RBC _____ |
| 73. thyroid (T4) _____ | 78. WBC _____ |
| 74. MCV _____ | 79. MCHC _____ |

Pathological Terms

Many diseases and disorders have some effect on the blood, but they are really diseases of other body systems. For example, diabetes is a disorder of the endocrine system, but its diagnosis includes an analysis of blood glucose levels.

Actual diseases of the blood are characterized by changes in the supply or characteristics of blood cells, presence of microorganisms affecting the blood, or presence or lack of certain substances in the blood. **Dyscrasia** is a general term for any disease of the blood with abnormal material present.

Anemia is a general term for a condition in which the red blood cells do not transport enough oxygen to the tissues due to a deficiency in number or quality of red blood cells. The most common types of anemia include:

- *Iron-deficiency anemia*, a lack of enough iron in the blood that affects the production of hemoglobin
- *Aplastic anemia*, a failure of the bone marrow to produce enough red blood cells
- *Pernicious anemia*, a condition in which the shape and number of the red blood cells changes due to a lack of sufficient vitamin B₁₂

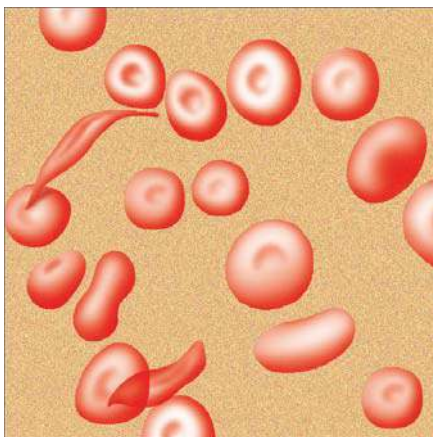


FIGURE 12-9 Characteristics of blood cells in certain anemias.

The Anemia Institute (www.anemiainstitute.org) provides detailed information about many types of anemia.

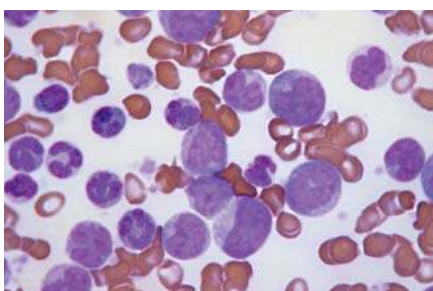


FIGURE 12-10 A blood smear showing chronic myelogenous leukemia (CML).

The Leukemia and Lymphoma Society's Web site (www.leukemia-lymphoma.org) has up-to-date information about various kinds of leukemia.

- **Sickle cell anemia**, a hereditary condition (usually in persons of African-American ancestry) characterized by sickle-shaped red blood cells and a breakdown in red blood cell membranes
- **Hemolytic anemia**, a disorder characterized by destruction of red blood cells
- **Posthemorrhagic anemia**, a disorder resulting from a sudden, dramatic loss of blood
- **Thalassemia**, an inherited disorder (usually in people of Mediterranean origin) resulting in an inability to produce sufficient hemoglobin (the most severe form of which is *Cooley's anemia*).

Figure 12-9 shows blood cell characteristics for some anemias.

Von Willebrand's disease is a hemorrhagic disorder in which there is a greater tendency to bleed due to the lack of a clotting factor called *Factor VIII*. Common symptoms are bruising and nosebleeds. Two other disorders of the blood that involve excessive bleeding are **hemophilia** and **thrombocytopenia**. Hemophilia is a hereditary lack of clotting Factor VIII (or, in 15 percent of the cases, a different clotting factor, Factor IX). Hemophiliacs can be treated with medications and transfusions. Thrombocytopenia is a bleeding disorder with insufficient platelets to aid in the clotting process. Thrombocytopenia is present in **purpura**, a condition with multiple tiny hemorrhages under the skin (Figure 12-10).

Small, flat, red spots called *petechiae* may indicate a deficiency in the number of platelets. There are a number of disorders of the blood cells or related substances in the blood. **Pancytopenia** is a condition with a low number of all blood cell components (red blood cells, white blood cells, and thrombocytes). The blood must be supplemented with transfusions. **Erythropenia** (also called *erythrocytopenia*) is a disorder with an abnormally low number of red blood cells. **Hemochromatosis** is a hereditary disorder leading to excessive buildup of iron in the blood. Because excessive iron in the blood can ultimately cause heart failure, people with this disorder have to limit their iron intake.

Polycythemia is a disease that causes an abnormal increase in red blood cells and hemoglobin. Various forms of the disease are associated with conditions such as hypertension and emphysema. **Anisocytosis** is characterized by red blood cells of differing sizes and shapes, a characteristic that prevents them from functioning normally. **Macrocytosis** is a disorder with abnormally large red blood cells present, and **microcytosis** is a disorder with abnormally small red blood cells present. **Poikilocytosis** is a disorder with irregularly-shaped red blood cells present. **Reticulocytosis** is a disorder with an abnormal number of immature erythrocytes present. **Hemolysis** is a disorder with breakdowns in the red blood cell membrane.

There are also disorders of white blood cells. The major disease involving white blood cells is **leukemia**. Leukemia is a general term for a disorder with an excessive increase in white blood cells in the bone marrow and bloodstream. People with leukemia may experience *remissions* (disappearances of the disease) and *relapses* (recurrences of the disease). Some leukemias (acute lymphocytic leukemia and chronic lymphocytic leukemia) occur in the lymph system.

The two most common leukemias of the bone marrow and bloodstream are AML and CML. *Acute myelogenous leukemia* (AML) is a disorder in which immature granulocytes (or **myeloblasts**) invade the bone marrow. *Chronic*

myelogenous leukemia (CML) or chronic granulocytic leukemia is a disorder in which mature and immature myeloblasts are present in the bloodstream and marrow. It is usually a slowly developing illness with a reasonably good prognosis. *Acute lymphocytic leukemia* (ALL) is a disorder with an abnormal number of immature lymphocytes. It is usually a disease of childhood and adolescence. The prognosis for recovery is very good. *Chronic lymphocytic leukemia* (CLL) appears mainly in adults and includes an abnormal number of mature lymphocytes.

Another disorder of the white blood cells is **granulocytosis**, an abnormal increase in granulocytes in the bloodstream, such as neutrophils during infection. Granulocytosis can also occur in combination with allergic conditions or certain infections, in which case it is called **eosinophilia**, an abnormal increase in eosinophilic granulocytes. **Basophilia** is an increase in basophilic granulocytes that is found in some types of leukemia. *Neutropenia* is a disorder with an abnormally low number of neutrophils in the bloodstream. *Neutrophilia* is a disorder with an abnormal increase in neutrophils.

Erythroblastosis fetalis, or Rh factor incompatibility between the mother and a fetus, can cause death to the fetus or a type of fetal anemia. A blood transfusion or treatment with medication can sometimes save the fetus.

Multiple myeloma is a malignant tumor of the bone marrow. It involves overproduction of certain white blood cells that produce immunoglobulins. The myeloma cells then migrate to different areas of the body where they cause tumors and destroy bony structures.

At www.multiplemyeloma.org, you can learn about the treatment options for multiple myeloma.

VOCABULARY REVIEW

In the previous section, you learned terms relating to pathology. Before going on to the exercises, review the terms below and refer to the previous section if you have any questions. Pronunciations are provided for certain terms. Sometimes information about where the word came from is included after the term. These etymologies (word histories) are for your information only. You do not need to memorize them.

Term	Definition
anemia [ă-NĒ-mē-ă] Greek <i>anaimia</i> from an-, without + <i>haima</i> , blood	Condition in which red blood cells do not transport enough oxygen to the tissues.
anisocytosis [ăn-Ī-sō-sī-TŌ-sīs] aniso-, unequal + cyt-, cell + -osis, condition	Condition with abnormal variation in the size of red blood cells.
basophilia [bā-sō-FĪL-ē-ă]	Condition with an increased number of basophils in the blood.
dyscrasia [dīs-KRĀ-zhē-ă] Greek, bad temperament	Any disease with abnormal particles in the blood.
eosinophilia [Ē-ō-sin-ō-FĪL-ē-ă]	Condition with an abnormal number of eosinophils in the blood.
erythroblastosis fetalis [ě-RĪTH-rō-blās-TŌ-sīs fē-TĀL-īs]	Incompatibility disorder between a mother with Rh negative and a fetus with Rh positive.

Term	Definition
erythropenia [ě-rĭth-rō-PĚ-nē-ă] erythro-, red blood cells + -penia, deficiency	Disorder with abnormally low number of red blood cells.
granulocytosis [GRĂN-yŭ-lō-sĭ-TŌ-sĭs] granulocyt(e) + -osis, condition	Condition with an abnormal number of granulocytes in the bloodstream.
hemochromatosis [HĚ-mō-krō-mă-TŌ-sĭs] hemo-, blood + chromat-, color + -osis	Hereditary condition with excessive iron buildup in the blood.
hemolysis [hē-MŎL-ĭ-sĭs] hemo-, blood + -lysis, destruction of	Disorder with breakdown of red blood cell membranes.
hemophilia [hē-mō-FĬL-ē-ă] hemo-, blood + -philia, attraction	Hereditary disorder with lack of clotting factor in the blood.
leukemia [lŭ-KĚ-mē-ă] leuk-, white + -emia, blood	General term for a number of disorders with excessive white blood cells in the bloodstream and bone marrow.
macrocytosis [MĂK-rō-sĭ-TŌ-sĭs] macro-, large + cyt- + -osis	Disorder with abnormally large red blood cells.
microcytosis [MĪK-rō-sĭ-TŌ-sĭs] micro-, small + cyt- + -osis	Disorder with abnormally small red blood cells.
multiple myeloma [mĭ-ě-LŎ-mă]	Malignant tumor of the bone marrow.
myeloblast [MĪ-ě-lō-blăst] myelo-, marrow + -blast, immature cell	Immature granulocytes.
pancytopenia [PĂN-sĭ-tō-PĚ-nē-ă] pan-, all + cyto- + -penia	Condition with a low number of blood components.
poikilocytosis [PŎY-kĭ-lō-sĭ-TŌ-sĭs] poikilo-, irregular + cyt- + -osis	Disorder with irregularly shaped red blood cells.
polycythemia [PŎL-ē-sĭ-THĚ-mē-ă] poly-, many + cyt- + -emia	Disorder with an abnormal increase in red blood cells and hemoglobin.
purpura [PŮR-pŭ-ră] Latin, purple	Condition with multiple tiny hemorrhages under the skin.
reticulocytosis [rě-TĪK-yŭ-lō-sĭ-TŌ-sĭs] reticulo-, fine network + cyt- + -osis	Disorder with an abnormal number of immature erythrocytes.
thalassemia [thăl-ă-SĚ-mē-ă] Greek <i>thalassa</i> , sea + -emia	Hereditary disorder characterized by inability to produce sufficient hemoglobin.
thrombocytopenia [THRŎM-bō-sĭ-tō-PĚ-nē-ă] thrombocyt(e) + -penia	Bleeding condition with insufficient production of platelets.
von Willebrand's [vŏn WĪL-lě-brăndz] disease After E. A. von Willebrand (1870–1949), Finnish physician	Hemorrhagic disorder with tendency to bleed from mucous membranes.

CASE STUDY

Reading the X-Rays

Next, the radiology report is added to Mr. Maynard's record, and the hematologist adds notes.

Critical Thinking

80. Does a CBC provide enough information for a diagnosis of anemia or chronic blood loss?
81. Is Rh factor important for an 83-year-old man? Why or why not?

RADIOLOGY: Abdomen: Adynamic ileus.

April 2, 2XXX: Chest; bibasilar changes compatible with a small pleural effusion. Increased density in the right lung and small localized density because of rotation.

December 4, 2XXX: Abdominal ultrasound; normal biliary examination. Bilateral multiple renal cysts. Liver; fatty texture.

In summary, I have initiated more workup for anemia. The possibilities include anemia of chronic disease, myelodysplasia, or chronic blood loss. If his workup is inconclusive, then he might require bone marrow aspiration and biopsy to establish the diagnosis.

PATHOLOGICAL TERMS EXERCISES

Spell It Correctly

The following terms are either spelled correctly or incorrectly. Put C in the space following correctly spelled words. Put the correct spelling in the space following incorrectly spelled words.

82. hemphilia _____

83. pancypenia _____

84. macrocytosis _____

85. anemia _____

86. aplastic anemia _____

87. eosinphilia _____

88. pupura _____

89. reticulocytosis _____

90. thrombocytenia _____

91. poikilocytosis _____

Check Your Knowledge

Circle T for true or F for false.

92. Sickle cell anemia is found primarily in people of Mediterranean origin. T F
93. All red blood cell disorders are inherited. T F
94. A sudden loss of blood can cause anemia. T F
95. Multiple myeloma is a form of cancer. T F
96. Rh factor incompatibility can cause hemochromatosis. T F
97. Pernicious anemia may result from a deficiency of vitamin B₁₂. T F

98. Leukemia and anemia are types of cancer. T F
99. Too many red blood cells can be a symptom of a disorder. T F

Find the Meaning

Describe the cause of each of the following forms of anemia.

- | | |
|-----------------------------|-------------------------|
| 100. aplastic anemia | 103. thalassemia |
| 101. iron-deficiency anemia | 104. sickle cell anemia |
| 102. pernicious anemia | |

CASE STUDY

Getting Confirmation

In addition to his other problems, Mr. Maynard has prostate cancer. His PSA has remained normal for a few years, so the cancer is thought to be in remission. However, the cause of the anemia was not confirmed. His diagnosis is also not confirmed, so a bone marrow biopsy is ordered. The bone marrow biopsy confirms aplastic anemia.

Critical Thinking

105. Describe the abnormality that the bone marrow biopsy reveals.
106. Does Mr. Maynard's condition require treatment before he has any surgery?

Surgical Terms

Surgery is not generally performed on the blood system. Sometimes venipuncture is considered a minor surgical procedure. (In this text, we have classified it as a diagnostic procedure.) The exceptions are **bone marrow biopsy** and **bone marrow transplant**.

A bone marrow biopsy is used in the diagnosis of various blood disorders, such as anemia and leukemia. A needle is introduced into the bone marrow cavity and marrow is extracted for examination.

A bone marrow transplant is performed for serious ailments, such as leukemia and cancer. In this procedure, a donor's marrow is introduced into the bone marrow of the patient. First, all the diseased cells are killed through extensive radiation and chemotherapy. After the donor's marrow is introduced, successful transplants result in healthy cells taking over the patient's marrow. Unsuccessful transplants may result in rejection of the marrow or a recurrence of the disease.

The National Marrow Donor Program (www.marrow.org) tells you how to become a bone marrow donor.

VOCABULARY REVIEW

In the previous section, you learned terms relating to surgery. Before going to the exercises, review the terms below and refer to the previous section if you have any questions. Pronunciations are provided for certain terms. Sometimes

information about where the word came from is included after the term. These etymologies (word histories) are for your information only. You do not need to memorize them.

Term	Definition
bone marrow biopsy	Extraction of bone marrow, by means of a needle, for observation.
bone marrow transplant	Injection of donor bone marrow into a patient whose diseased cells have been killed through radiation and chemotherapy.

Pharmacological Terms

Medications that directly affect the work of the blood system are **anticoagulants** (to prevent blood clotting); **thrombolytics** (to dissolve blood clots); **coagulants** or clotting agents (to aid in blood clotting); and **hemostatics** (to stop bleeding, such as vitamin K). Anticoagulants are administered before most types of surgeries to prevent emboli. Blood flow is affected by vasoconstrictors and vasodilators, two medications given for cardiovascular problems.

Chemotherapy, therapy that uses drugs, is used to cause a **remission** (disappearance of the disease) in leukemia. Sometimes more treatment is needed when a **relapse** (recurrence of the disease) occurs. Table 12-4 lists common pharmaceutical agents used in treating blood disorders.

TABLE 12-4 Some Pharmaceutical Agents Used to Treat Blood Disorders

Drug Class	Purpose	Generic	Trade Name
anticoagulant	dissolves blood clots	warfarin heparin dipyrimadole enoxaparin phytonadione, vitamin K	Coumadin various Persantine Lovenox Mephyton
clotting agent; coagulant	aids in clotting blood		
hemostatic	stops bleeding	aminocaproic acid recombinant factor VIIa	Amicar NovoSeven
thrombolytic	dissolves blood clots	streptokinase urokinase alteplace	Streptase Abbokinase Activase

VOCABULARY REVIEW

In the previous section, you learned terms relating to pharmacology. Before going on to the exercises, review the terms below and refer to the previous section if you have any questions. Pronunciations are provided for certain terms. Sometimes information about where the word came from is included after the term. These etymologies (word histories) are for your information only. You do not need to memorize them.

Term	Definition
anticoagulant [ǺN-tē-kō-ǺG-yū-lěnt] anti-, against + coagulant	Agent that prevents formation of blood clots.
coagulant [kō-ǺG-yū-lěnt] Latin <i>coagulo</i> , to curdle	Clotting agent.
hemostatic [hē-mō-STĀT-ĭk] hemo-, blood + -static, maintaining a state	Agent that stops bleeding.
relapse [RĒ-lāps] From Latin <i>relabor</i> , to slide back	Recurrence of a disease.
remission [rē-MĪSH-ŭn] Latin <i>remissio</i> , a relaxation	Disappearance of a disease for a time.
thrombolytic [thrōm-bō-LĪT-ĭk] thrombo-, thrombus + -lytic, a loosening	Agent that dissolves blood clots.

CASE STUDY

Coordinating Prescription Medication

Mr. Maynard's medication list at admission is:

Cardura 4 mg. p.o. q.h.s.

Ventolin unit does t.i.d.

Atrovent unit does t.i.d.

Ceftin 250 mg. b.i.d. prior to admission.

Magnesium citrate b.i.d.

Lactulose 30 cc p.o. b.i.d.

Cardura is for his high blood pressure and prostate problems. Ventolin and Atrovent are prescribed for his

respiratory symptoms. Ceftin is an antibiotic for a urinary tract infection. Magnesium citrate and lactulose are laxatives.

Critical Thinking

- 107.** Aspirin is known to promote some bleeding. Should Mr. Maynard use aspirin for pain?
- 108.** What vitamin might improve Mr. Maynard's condition?

PHARMACOLOGICAL TERMS EXERCISES

Check Your Knowledge

Fill in the blanks.

- 109.** Hemophiliacs require _____ and _____ to control bleeding.
- 110.** A prescription for someone with coronary artery disease might include a(n) _____.

111. If medication is not taken regularly, a(n) _____ of a disease might occur.
112. Sometimes the temporary disappearance of a disease, called a(n) _____, is unexplained.

CHALLENGE SECTION

The form shown in Figure 12-8 gives results for a patient and expected ranges for lab tests done in a large lab service.

Critical Thinking

113. What tests, if any, are abnormal?
114. The laboratory was instructed to do a T3 and T4 uptake test. What was the patient's physician trying to determine?

TERMINOLOGY IN ACTION

Alicia Minot is a 21-year-old student who is prone to migraine headaches. Her latest visit to her family doctor included a general physical and a CBC as well as a urinalysis. All test results were normal except for a low hemoglobin count. Alicia complains that Tylenol does not relieve her headaches and she wants to use her mother's aspirin. Do you think the doctor will recommend aspirin? Why or why not? What are some steps Alicia can take in her daily life to raise her hemoglobin count?

USING THE INTERNET

Go to the Web site of the Aplastic Anemia Association (www.aplastic.org). Choose one of their online articles and write a paragraph summarizing its content.

CHAPTER REVIEW

The material that follows is to help you review all the material in this chapter.

Matching

Write the letter of the meaning of the term in the space provided.

- | | |
|---------------------------|---|
| 115. _____ erythropoietin | a. Protein in the plasma that aids in clotting. |
| 116. _____ fibrinogen | b. Substance released by basophils and eosinophils; involved in allergic reactions. |
| 117. _____ gamma globulin | c. Protein that aids in forming a fibrin clot. |
| 118. _____ histamine | d. Hormone released by the kidneys to stimulate red blood cell production. |
| 119. _____ plasmapheresis | e. A protein that arises in lymphatic tissue and functions as part of the immune system. |
| 120. _____ thromboplastin | f. Process of removing blood from a person, centrifuging it, and returning only red blood cells to that person. |

Complete the Sentence

Circle the term that best describes the *italicized* description of the correct answer

121. Mrs. Sommers is *lacking the Rh factor on the surface of her red blood cells*, therefore she is (Rh-negative, Rh-neutral, Rh-positive).
122. Mr. Martinez has *an increase in his platelet count* or (thrombocytes, granulocytes, megakaryocytes).
123. *The liquid portion of unclotted blood* is called (serum, plasma, albumin).
124. The physician informed Mrs. Larkin that *the protein in the red cells essential to the transport of oxygen* was low. He was referring to her (red blood cell, hematocrit, hemoglobin) level.
125. *Basophils, eosinophils and neutrophils* are all considered (granulocytes, agranulocytes, hematocystoblasts).
126. The process of *infusing donor blood into a person needing blood* is known as: (plasmapheresis, agglutination, transfusion).

Root Out the Meaning

Separate the following terms into word parts; define each word part.

127. eosinophilic _____
128. hemolysis _____
129. hemocytometer _____
130. pancytopenia _____
131. phlebitis _____
132. phlebotomy _____
133. phlebectomy _____
134. hematoma _____
135. anisocytosis _____
136. thrombophlebitis _____

- 137. hemostatic _____
- 138. venospasm _____
- 139. hemogram _____
- 140. hemolytic _____
- 141. anemia _____
- 142. phlebography _____
- 143. phlebectasia _____
- 144. hemorrhage _____
- 145. hemopathy _____
- 146. hematopoiesis _____
- 147. hematology _____
- 148. plasmapheresis _____
- 149. sideropenia _____
- 150. basophil _____

Complete the Sentence

Circle the term that best describes the *italicized* description of the correct answer.

- 151. A disorder in which there are *excessive red blood cells* is known as: (erythrocytopenia, polycythemia, leukemia).
- 152. This test measures the amount of *protein essential to the transport of oxygen*. (hematocrit, hemogram, hemoglobin).
- 153. A *blood disorder with a tendency to hemorrhage* is known as (hemophilia, anemia, dyscrasia).
- 154. The test results indicated a *fragmentation of red blood cells* or (eosinosis, erythroclasis, erytholysis).
- 155. The term *hemocytoblasts* refers to (red cells, stem cells, white cells).
- 156. The *largest of the white blood cells* is called a (neutrophil, basophil, monocyte).
- 157. These cells *break off from larger cells in the red bone marrow* and assist in blood clotting (megakaryocytes, agranulocytes, proerythroblasts).
- 158. A MCV test can indicate (microcytic or macrocytic, hyperchromic or hypochromic) anemia.

Building Your Medical Vocabulary

Construct a word with each of the following meanings. Some of the word parts you need to use are in Chapters 1 and 2.

- 159. An immature white blood cell _____
- 160. Dissolution of red blood cells _____
- 161. The study of the structure of red blood cells _____
- 162. A normal (red) blood cell _____
- 163. A cell that ingests bacteria and other particles _____
- 164. Irregularly shaped red blood cells _____
- 165. A spherical red blood cell _____
- 166. White blood cell cancer _____

167. Removal of white blood cells from drawn blood _____

168. Forming new blood cells _____

Matching

Indicate whether the abbreviation refers to red cells, white cells or platelets.

R = red cells

W = white cells

P = platelets

169. ____ APTT

174. ____ ESR

170. ____ seg

175. ____ diff

171. ____ SR

176. ____ mono

172. ____ PLT

177. ____ MCHC

173. ____ HCT

178. ____ PMN, poly

Matching

Place the letter of the pharmaceutical agents used to treat blood disorders to the left in the blank and then state the drugs purpose in the blank after the drug class.

179. Thrombolytic: _____

a. heparin

180. Coagulant: _____

b. streptokinase

181. Hemostatic: _____

c. vitamin K

182. Anticoagulant: _____

d. aminocaproic acid

True or False

Indicate in the blank whether the statement is true or false.

183. The disappearance of a disease for a time is known as submission _____.

184. A bone marrow transplant is the extraction of bone marrow, by means of a needle, for observation _____.

185. A malignant tumor of the bone marrow is referred to as multiple myeloma _____.

186. Erythroblastosis fetalis is the a condition in which a fetus forms new red blood cells _____.

187. Purpura is a condition in which multiple tiny hemorrhages form under the skin _____.

188. Aplastic anemia is the failure of the bone marrow to produce enough red blood cells _____.

189. Hemodialysis is the internal dialysis performed by separating solid substances and water from the blood _____.

190. Agglutination is the clumping of cells and particles in the blood _____.

191. Plasma is the liquid portion of clotted blood _____.

192. A hereditary condition with excessive iron buildup in the blood is known as sickle cell anemia _____.

Check Your Spelling

If the word is spelled correctly place a C in the blank. If the term is not spelled correctly, place the correct spelling in the blank.

193. miloblast _____

195. neutraphil _____

194. hematoglobin _____

196. granulocytosis _____

197. histamean _____
 198. antiglobulin _____
 199. remission _____
 200. thalassemia _____

201. anesocytosis _____
 202. reticulocytosis _____
 203. venapuncture _____
 204. phlebotomy _____

DEFINITIONS

Define the following terms and combining forms. Review the chapter before starting. Make sure you know how to pronounce each term as you define it. The blue words in curly brackets are references to the Spanish Glossary available online at www.mhhe.com/medterm3e.

WORD

- | | | |
|--|---|--|
| 205. agglutin(o) | 226. coagulation [kō-äg-yū-LĀ-shŭn] {coagulación} | 243. globulin [GLÖB-yū-lĭn] {globulina} |
| 206. agglutination [ă-glŭ-tĭ-NĀ-shŭn] {aglutinación} | 227. complete blood count (CBC) | 244. granulocyte [GRĀN-yū-lō-sĭt] |
| 207. agglutininogen [ă-glŭ-TĪN-ō-jĕn] {aglutinógeno} | 228. dyscrasia [dĭs-KRĀ-zhē-ă] {discrasia} | 245. granulocytosis [GRĀN-yū-lō-sĭ-TÖ-sĭs] {granulocitosis} |
| 208. agranulocyte [ă-GRĀN-yū-lō-sĭt] {agranulocito} | 229. electrophoresis [ē-lĕk-trō-FÖR-ē-sĭs] {electroforesis} | 246. hematocrit [HĒ-mă-tō-krit, HĒM-ă-tō-krit] {hematócrito} |
| 209. albumin [ăl-BYŪ-mĭn] {albúmina} | 230. eosino | 247. hematocytoblast [HĒ-mă-tō-SĪ-tō-blăst] {hematocitoblasto} |
| 210. anemia [ă-NEĒ-mē-ă] {anemia} | 231. eosinophil [ē-ō-SĪN-ō-fĭl] {eosinófilo} | 248. heme [hēm] |
| 211. anisocytosis [ăn-Ī-sō-sĭ-TÖ-sĭs] {anisocitosis} | 232. eosinophilia [Ē-ō-sĭn-ō-FĪL-ē-ă] {eosinofilia} | 249. hemo, hemat(o) |
| 212. anticoagulant [ĂN-tē-kō-ĂG-yū-lĕnt] | 233. erythr(o) | 250. hemochromatosis [HĒ-mō-krō-mă-TÖ-sĭs] |
| 213. antiglobulin [ĂN-tē-GLÖB-yū-lĭn] test | 234. erythroblastosis fetalis [ĕ-RĪTH-rō-blăs-TÖ-sĭs fē-TĀL-ĭs] | 251. hemoglobin [hē-mō-GLÖ-bĭn] {hemoglobina} |
| 214. basophil [BĀ-sō-fĭl] {basófilo} | 235. erythrocyte [ĕ-RĪTH-rō-sĭt] {eritrocito} | 252. hemolysis [he-MÖL-ĭ-sĭs] {hemólisis} |
| 215. basophilia [bā-sō-FĪL-ē-ă] {basofilia} | 236. erythrocyte sedimentation rate (ESR) | 253. hemophilia [hē-mō-FĪL-ē-ă] {hemofilia} |
| 216. biochemistry panel | 237. erythropenia [ĕ-rĭth-rō-PĒ-nē-ă] {eritropenia} | 254. hemostatic [hē-mō-STĀT-ĭk] |
| 217. blood [blŭd] {sangre} | 238. erythropoietin [ĕ-rĭth-rō-POY-ē-tĭn] {eritropoyetina} | 255. heparin [HĒP-ă-rĭn] {heparina} |
| 218. blood chemistry | 239. fibrin [FĪ-brĭn] clot | 256. histamine [HĪS-tă-mĕn] {histamine} |
| 219. blood culture | 240. fibrinogen [fĭ-BRĪN-ō-jĕn] {fibrinógeno} | 257. leuk(o) |
| 220. blood indices [ĪN-dĭ-sēz] | 241. gamma globulin [GĀ-mă GLÖB-yū-lĭn] | 258. leukocyte [LŪ-kō-sĭt] {leucocito} |
| 221. blood types or groups | 242. globin [GLÖ-bĭn] {globina} | 259. leukemia [lŭ-KĒ-mē-ă] {leucemia} |
| 222. bone marrow biopsy | | |
| 223. bone marrow transplant | | |
| 224. chemistry profile | | |
| 225. coagulant [kō-ĂG-yū-lĕnt] | | |

WORD

- | | | |
|--|--|---|
| 260. lymphocyte [LĪM-fō-sīt]
{ linfocito } | 273. plasmapheresis [PLĀZ-mă-fē-RE-sīs] { plasmaféresis } | 291. serum [SĒR-ŭm] { suero } |
| 261. macrocytosis [MĀK-rō-sī-TŌ-sīs] { macrocitosis } | 274. platelet [PLĀT-lēt] { plaqueta } | 292. SMA (sequential multiple analyzer) |
| 262. megakaryocyte [mĕg-ă-KĀR-ē-ō-sīt]
{ megacariocito } | 275. platelet count (PLT) | 293. stem cell |
| 263. microcytosis [MĪK-rō-sī-TŌ-sīs] { microcitosis } | 276. poikilocytosis [PÖY-kī-lō-sī-TŌ-sīs] { poiquilocitosis } | 294. thalassemia [thăl-ă-SĒ-mē-ă]
{ talasemia } |
| 264. monocyte [MŌN-ō-sīt]
{ monocito } | 277. polycythemia [PÖL-ē-sī-THĒ-mē-ă] { policetemia } | 295. thromb(o) |
| 265. multiple myeloma [mī-ē-LŌ-mă] | 278. prothrombin [prō-THRŌM-bĭn] { protrombina } | 296. thrombin [THRŌMB-ĭn]
{ trombina } |
| 266. myeloblast [MĪ-ē-lō-blăst]
{ mieloblasto } | 279. prothrombin time (PT) | 297. thrombocyte [THRŌM-bō-sīt]
{ trombocito } |
| 267. neutrophil [NŪ-trō-fĭl]
{ neutrófilo } | 280. purpura [PŪR-pū-ră] { púrpura } | 298. thrombocytopenia [THRŌM-bō-sī-tō-PĒ-nē-ă] |
| 268. pancytopenia [PĀN-sī-tō-PĒ-nē-ă] { pancitopenia } | 281. red blood cell | 299. thrombolytic [thrŏm-bō-LĪT-ĭk] |
| 269. partial thromboplastin time (PTT) | 282. red blood cell count | 300. thromboplastin [thrŏm-bō-PLĀS-tĭn] |
| 270. phag(o) | 283. red blood cell morphology | 301. transfusion [trăns-FYŪ-zhŭn]
{ transfusión } |
| 271. phlebotomy [flĕ-BŌT-ō-mē]
{ flebotomía } | 284. relapse [RĒ-lăps] | 302. venipuncture [VĒN-ĭ-pŭnk-chŭr, VĒ-nĭ-pŭnk-chŭr] { venipuntura } |
| 272. plasma [PLĀZ-mă] { plasma } | 285. remission [rē-MĪSH-ŭn] | 303. von Willebrand's [vŏn WĪL-lĕ-brăndz] disease |
| | 286. reticulocytosis [rē-TĪK-yŭ-lō-sī-TŌ-sīs] { reticulocitosis } | 304. white blood cell |
| | 287. Rh factor | |
| | 288. Rh-negative | |
| | 289. Rh-positive | |
| | 290. sedimentation rate (SR) | |

Abbreviations

Write the full meaning of each abbreviation.

ABBREVIATION

- | | | |
|------------|-------------------|--------------------|
| 305. APTT | 314. GM-CSF | 323. PMN, poly |
| 306. baso | 315. HCT, Hct | 324. PT |
| 307. BCP | 316. HGB, Hgb, HB | 325. PTT |
| 308. BMT | 317. MCH | 326. RBC |
| 309. CBC | 318. MCHC | 327. SR, sed. rate |
| 310. diff | 319. MCV | 328. seg |
| 311. eos | 320. mono | 329. WBC |
| 312. ESR | 321. PCV | |
| 313. G-CSF | 322. PLT | |

Name _____ Date _____

Chapter 12: Word- Building (20 questions—1 pts. each)

Using the following combining forms, complete the word that best fits the definition of each word relating to the blood system listed below. Combining forms may be used more than once.

agglutin(o)	hemat(o)
eosino	leuk(o)
erythr(o)	phag(o)
hemo	thromb(o)

1. Deficiency of eosinophils: _____ penia
2. Cleansing of the blood: _____ catharsis
3. Excess blood in the bladder: _____ cystis
4. Formation of red blood cells: _____ poiesis
5. White blood cell: _____ cyte
6. Stimulating the formation of agglutinin: _____ genic
7. Hemorrhage into spinal fluid: _____ myelia
8. Vision abnormality with objects appearing red: _____ opsia
9. Removal of white blood cells: _____ apheresis
10. Reddening of the skin: _____ derma
11. Cell that ingests things: _____ cyte
12. Dialysis with removal of substances from the blood: _____ dialysis
13. Producing red: _____ genic
14. Medical specialty concerned with the blood system: _____ logy
15. Destruction of red blood cells: _____ phagia
16. Inflammation of veins with thrombi: _____ phlebitis
17. Excessive fear of eating: _____ phobia
18. Fragmentation of red blood cells: _____ clasis
19. Death of vessel walls due to a thrombus: _____ necrosis
20. Disorder with excessive white blood cells: _____ emia