Blood Cells, Immunity, and Blood Coagulation

The following table of normal test values can be referenced throughout Unit VI.

Test	Normal Values
Bleeding time (template)	2-7 minutes
Erythrocyte count	Male: 4.3-5.9 million/μl^3
	Female: 3.5-5.5 million/μl^3
Hematocrit	Male: 41%-53%
	Female: 36%-46%
Hemoglobin, blood	Male: 13.5-17.5 g/dl
	Female: 12.0-16.0 g/dl
Mean corpuscular hemoglobin	25.4-34.6 pg/cell
Mean corpuscular hemoglobin concentration	31%-36% hemoglobin/cell
Mean corpuscular volume	80-100 fl
Reticulocyte count	0.5%-1.5% of red blood cells
Platelet count	150,000-400,000/μl^3
Leukocyte count and differential	
Leukocyte count	4500-11,000/μl^3
Neutrophils	54%-62%
Eosinophils	1%-3%
Basophils	0-0.75%
Lymphocytes	25%-33%
Monocytes	3%-7%
Partial thromboplastin time (activated)	25-40 seconds
Prothrombin time	11-15 seconds
Bleeding time	2-7 minutes

1. A 40-year-old woman visits the clinic complaining of fatigue. She had recently been treated for an infection. Her laboratory values are as follows: red blood cell (RBC) count, 1.8 × 10^6/μl; hemoglobin (Hb), 5.2 g/dl; hematocrit (Hct), 15; white blood cell (WBC) count, 7.6 × 10^3/μl; platelet count, 320,000/μl; mean corpuscular volume (MCV), 92 fL; and reticulocyte count, 24%. What is the most likely explanation for this presentation?

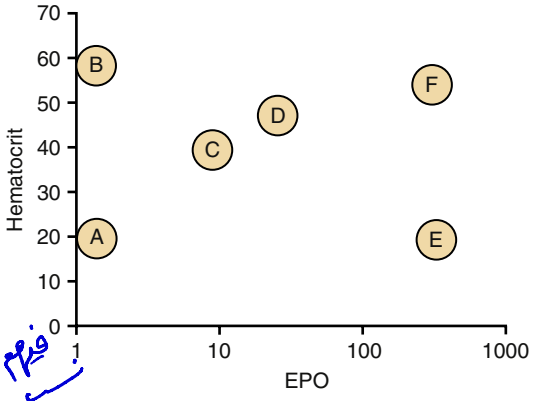
   A) Aplastic anemia
   B) Hemolytic anemia
   C) Hereditary spherocytosis
   D) B_{12} deficiency

2. What RBC enzyme facilitates transport of carbon dioxide (CO_2)?

   A) Myeloperoxidase
   B) Carbonic anhydrase
   C) Superoxide dismutase
   D) Globin reductase

Questions 3–6

Which points in the figure below most closely define the following conditions? Normal erythropoietin (EPO) levels are approximately 10.



3. Olympic marathoner
4. Aplastic anemia
5. End-stage renal disease
6. Polycythemia vera

7. How many oxygen *atoms* can be transported by each hemoglobin molecule?

   A) 2
   B) 4
   C) 8
   D) 16

8. During the second trimester of pregnancy, where is the predominant site of RBC production?
   A) Yolk sac
   B) Bone marrow
   C) Lymph nodes
   D) Liver

9. What function do vitamin B_{12} and folic acid perform that is critical to hematopoiesis?
   A) Support porphyrin production
   B) Serve as cofactors for iron uptake
   C) Support terminal differentiation of erythroid and myeloid cells
   D) Support production of thymidine triphosphate

10. A 62-year-old man complains of headaches, visual difficulties, and chest pains. Physical examination reveals a red complexion and a large spleen. His complete blood cell count (CBC) is as follows: Hct, 58%; WBC, 13,300/μl; and platelets, 600,000/μl. His arterial oxygen saturation is 97% on room air. Which treatment would you recommend?
    A) Chemotherapy
    B) Phlebotomy
    C) Iron supplement
    D) Inhaled oxygen therapy

51. phlebotomy done in polycythemia vera

11. A 38-year-old healthy woman comes to you for a routine visit. She has spent the past 2 months hiking through the Himalayas and climbed to the base camp of Mount Everest. Which results would you expect to see on her CBC?

	Hematocrit	RBC count	WBC count	MCV
A)	↑	↑	↑	↑
B)	↑	↑	↔	↑
C)	↑	↑	↔	↔
D)	↑	↔	↔	↔
E)	↔	↑	↑	↔
F)	↑	↔	↑	↑
G)	↔	↑	↔	↑

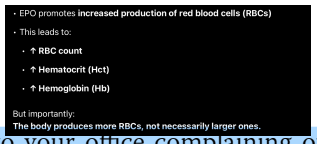
12. A 34-year-old man with schizophrenia has had chronic fatigue for 6 months. He has a good appetite but has refused to eat vegetables for 1 year because he hears voices saying that vegetables are poisoned. His physical and neurological examinations are normal. His hemoglobin level is 9.1 g/dl, his leukocyte count is 10,000/μl³, and his MCV is 122. What is the most likely diagnosis?
    A) Acute blood loss
    B) Sickle cell anemia
    C) Aplastic anemia
    D) Hemolytic anemia
    E) Folic acid deficiency

13. What immunologic signal causes mast cells to release their granular contents (e.g., heparin, histamine, bradykinin, serotonin, and leukotrienes)?
    A) Release of interleukin (IL)-1 by macrophages
    B) Cross-linking of cell surface–bound immunoglobulin E (IgE) by antigen
    C) Binding of antigen-antibody complexes to immunoglobulin G (IgG) receptors
    D) Binding of tissue factor to surface glycoproteins

14. A 24-year-old African American man comes to the emergency department 3 hours after the onset of severe back and chest pain. These problems started while he was skiing. He lives in Los Angeles and had a previous episode of these symptoms 5 years ago while visiting Wyoming. He is in obvious pain. Laboratory studies show the following values:
    Hemoglobin = 11 g/dl
    Leukocyte count = 22,000/μl³
    Reticulocyte count = 25%

    What is this patient's diagnosis?
    A) Acute blood loss
    B) Sickle cell anemia
    C) Anemia of chronic disease
    D) End-stage renal disease

15. After a person is placed in an atmosphere with low oxygen, how long does it take for increased numbers of reticulocytes to develop?
    A) 6 hours
    B) 12 hours
    C) 3 days
    D) 5 days
    E) 2 weeks



16. A patient presents to your office complaining of extreme fatigue and shortness of breath on exertion that has gradually worsened during the past 2 weeks. Physical examination reveals a well-nourished woman who appears comfortable but somewhat short of breath. Her vital signs include a pulse of 120, a respiratory rate of 20, and blood pressure of 120/70. When she stands up, her pulse increases to 150 and her blood pressure falls to 80/50. Her hematologic values are as follows: Hb, 7 g/dl; Hct, 20%; RBC count, 2 × 10⁶/μl; and platelet count, 400,000/μl. On a peripheral smear, her RBCs are microcytic and hypochromic. What is your diagnosis?
    A) Aplastic anemia
    B) Renal failure
    C) Iron deficiency anemia
    D) Sickle cell anemia
    E) Megaloblastic anemia

17. Which phagocytes can extrude digestion products and continue to survive and function for many months?
    A) Neutrophils
    B) Basophils
    C) Macrophages
    D) Eosinophils

18. During an inflammatory response, what is the correct order of cellular events?
    A) Filtration of monocytes from blood, increased production of neutrophils, activation of tissue macrophages, infiltration of neutrophils from the blood
    B) Activation of tissue macrophages, infiltration of neutrophils from the blood, infiltration of monocytes from blood, increased production of neutrophils
    C) Increased production of neutrophils, activation of tissue macrophages, infiltration of neutrophils from the blood, infiltration of monocytes from blood
    D) Infiltration of neutrophils from the blood, activation of tissue macrophages, infiltration of monocytes from blood, increased production of neutrophils

19. A 45-year-old man presents to the emergency department with a 2-week history of diarrhea that has gotten progressively worse during the past several days. He has minimal urine output and is admitted to the hospital for dehydration. His stool specimen is positive for parasitic eggs. Which type of WBC would have an elevated number?
    A) Eosinophils
    B) Neutrophils
    C) T lymphocytes
    D) B lymphocytes
    E) Monocytes

20. A 24-year-old man came to the emergency department with a broken leg. A blood test revealed his WBC count to be 22 × 10^3/µl. Five hours later, a second blood test revealed values of 7 × 10^3/µl. What is the cause of the increased WBC count in the first test?
    A) Increased production of WBCs by the bone marrow
    B) Release of pre-formed, mature WBCs into the circulation
    C) Decreased destruction of WBCs
    D) Increased production of selectins

21. A 62-year-old man who was known to have a normal blood cell count and differential count 3 months ago presents with pallor, bone pain, bruising, and a WBC count of 42,000. Eighty-five percent of cells in the circulation appear to be immature granulocytes. What is the diagnosis?
    A) Acute lymphocytic leukemia
    B) Acute myelocytic leukemia
    C) Chronic lymphocytic leukemia
    D) Chronic myelocytic leukemia

22. Adhesion of WBCs to the endothelium is
    A) Due to a decrease in selectins
    B) Dependent on activation of integrins
    C) Due to the inhibition of histamine release
    D) Greater on the arterial than on the venous side of the circulation

23. A 65-year-old alcoholic experienced chest pain and cough with an expectoration of sputum. A blood sample revealed that his WBC count was 21,000/µl. What is the origin of these WBCs?
    A) Pulmonary alveoli
    B) Bronchioles
    C) Bronchi
    D) Trachea
    E) Bone marrow

24. Where does the transmigration of WBCs occur in response to infectious agents?
    A) Arterioles
    B) Lymphatic ducts
    C) Venules
    D) Inflamed arteries

25. An 8-year-old boy frequently comes to the clinic for persistent skin infections that do not heal within a normal time frame. He had a normal recovery from the measles. A check of his antibodies after immunizations yielded normal antibody responses. A defect in which of the following cells would most likely be the cause of the continual infections?
    A) B lymphocytes
    B) Plasma cells
    C) Neutrophils
    D) Macrophages
    E) CD4 T lymphocytes

26. Which cell type migrates into inflammatory sites to clean up necrotic tissue and direct tissue remodeling?
    A) Neutrophil
    B) Macrophage
    C) Dendritic cell
    D) Eosinophil

27. A 3-year-old child who has had frequent ear infections is found to have reduced immunoglobulin levels and is unresponsive to vaccination with tetanus toxoid. However, the child has normal skin test reactivity (delayed redness and induration) to a common environmental antigen. Which cell lineage is not functioning normally?
    A) Macrophages
    B) Helper T cells
    C) Cytotoxic T cells
    D) B cells

28. Patients with human immunodeficiency virus (HIV) exhibit abnormal functioning of which of the following mechanisms?
    A) Antibody production only
    B) T cell–mediated cytotoxicity only
    C) Degranulation of appropriately stimulated mast cells
    D) Both antibody production and T cell–mediated cytotoxicity

29. What is the term for binding of IgG and complement to an invading microbe to facilitate recognition?
    A) Chemokinesis
    B) Opsonization
    C) Phagolysosome fusion
    D) Signal transduction

30. Presentation of antigen on major histocompatibility complex (MHC)-I by a cell will result in which of the following?
    A) Generation of antibodies
    B) Activation of cytotoxic T cells
    C) Increase in phagocytosis
    D) Release of histamine by mast cells

31. Which of the following applies to patients with acquired immunodeficiency virus (AIDS)?
    A) Able to generate a normal antibody response
    B) Increased helper T cells
    C) Increased secretion of interleukins
    D) Decrease in helper T cells

32. Fluid exudation into the tissue in an acute inflammatory reaction is due to which of the following?
    A) Decreased blood pressure
    B) Decreased protein in the interstitium
    C) Obstruction of the lymph vessels
    D) Increased clotting factors
    E) Increased vascular permeability

33. What will occur after presentation of antigen by a macrophage?
    A) Direct generation of antibodies
    B) Activation of cytotoxic T cells
    C) Increase in phagocytosis
    D) Activation of helper T cells

34. CD4 is a marker of which of the following?
    A) B cells
    B) Cytotoxic T cells
    C) Helper T cells
    D) An activated macrophage
    E) A neutrophil precursor

35. What is the function of IL-2 in the immune response?
    A) Binds to and presents antigen
    B) Stimulates proliferation of T cells
    C) Kills virus-infected cells
    D) Is required for an anaphylactic response

36. Which of the following is true about helper T cells?
    A) They are activated by the presentation of antigen by an infected cell
    B) They require the presence of a competent B-cell system
    C) They destroy bacteria by phagocytosis
    D) They are activated by the presentation of antigen by macrophage or dendritic cells

37. Which of the following applies to cytotoxic T cells?
    A) They require the presence of a competent B-lymphocyte system
    B) They require the presence of a competent suppressor T-lymphocyte system
    C) They are activated by the presentation of antigen by an infected cell
    D) They destroy bacteria by initiating macrophage phagocytosis

38. A 9-year-old girl has nasal discharge and itching of the eyes in the spring every year. An allergist performs a skin test using a mixture of grass pollens. Within a few minutes the girl exhibits a focal redness and swelling at the test site. This response is most likely due to
    A) Antigen–antibody complexes being formed in blood vessels in the skin
    B) Activation of neutrophils due to injected antigens
    C) Activation of CD4 helper cells and the resultant generation of specific antibodies
    D) Activation of cytotoxic T lymphocytes to destroy antigens

39. Activation of the complement system results in which action?
    A) Binding of the invading microbe with IgG
    B) Inactivation of eosinophils
    C) Decreased tissue levels of complement
    D) Generation of chemotactic substances

40. Which statement is true concerning erythroblastosis fetalis (hemolytic disease of the newborn [HDN])?
    A) HDN occurs when an Rh-positive mother has an Rh-negative child
    B) HDN is prevented by giving the mother a blood transfusion
    C) A complete blood transfusion after the first birth will prevent HDN
    D) The father of the child must be Rh positive

41. Which statement is true?
    A) In a transfusion reaction, agglutination of the recipient blood occurs
    B) Shutdown of the kidneys after a transfusion reaction occurs slowly
    C) Blood transfusion of Rh-positive blood into any Rh-negative recipient will result in an immediate transfusion reaction
    D) A person with type AB Rh-positive blood is considered a universal recipient

42. A woman whose blood type is A, Rh positive, and a man whose blood type is B, Rh positive, come to the clinic with a 3-year-old girl whose blood type is O, Rh negative. What can be said about the relationship of these two adults to this child?
    A) The woman can be the child's natural mother, but the man cannot be the natural father
    B) The man can be the child's natural father, but the woman cannot be the natural mother
    C) Neither adult can be the natural parent of this child
    D) This couple can be the natural parents of this child

43. What is the appropriate treatment for an infant born with severe HDN (erythroblastosis fetalis)?
    A) Passive immunization with anti-Rh(D) immunoglobulin
    B) Immunization with Rh(D) antigen
    C) Exchange transfusion with Rh(D)-positive blood
    D) Exchange transfusion with Rh(D)-negative blood

44. Chronic allograft rejection results primarily from the actions of what effector cell type?
    A) Activated macrophages
    B) Helper T lymphocytes
    C) Cytotoxic T lymphocytes
    D) Dendritic cells

45. Which of the following transfusions will result in an immediate transfusion reaction?
    A) O Rh-negative whole blood to an O Rh-positive patient
    B) A Rh-negative whole blood to a B Rh-negative patient
    C) AB Rh-negative whole blood to an AB Rh-positive patient
    D) B Rh-negative whole blood to a B Rh-negative patient

46. Which blood unit carries the least risks for inducing an immediate transfusion reaction into a B-positive (B, rhesus positive) recipient?
    A) Whole blood A positive
    B) Whole blood O positive
    C) Whole blood AB positive
    D) Packed red blood cells O positive
    E) Packed red blood cells AB negative

47. What condition leads to a deficiency in factor IX that can be corrected by an intravenous injection of vitamin K?
    A) Classic hemophilia
    B) Hepatitis B
    C) Bile duct obstruction
    D) Genetic deficiency in antithrombin III

48. Which transfusion will result in a transfusion reaction? Assume that the patient has never had a transfusion.
    A) Type O Rh-negative packed cells to an AB Rh-positive patient
    B) Type A Rh-positive packed cells to an A Rh-negative patient
    C) Type AB Rh-positive packed cells to an AB Rh-positive patient
    D) Type A Rh-positive packed cells to an O Rh-positive patient

49. Which antigens must be matched optimally between donors and recipients of solid organ transplants?
    A) Class I human leukocyte antigen (HLA) antigens only
    B) Class II HLA antigens only
    C) Class I and Class II HLA antigens only
    D) Class I and Class II HLA antigens and ABO antigens

50. A 55-year-old man who has been undergoing stable and successful anticoagulation with warfarin for recurrent deep vein thrombosis is treated for pneumonia, and 8 days later he presents with lower intestinal bleeding. His prothrombin time is quite prolonged. What is the appropriate therapy?
    A) Treatment with tissue plasminogen activator
    B) Infusion of calcium citrate
    C) Treatment with fresh frozen plasma and vitamin K
    D) Rapid infusion of protamine

51. A woman whose blood type is A positive and who has always been healthy just delivered her second child. The father's blood type is O negative. Because the child's blood type is O negative (O, Rh negative), what would you expect to find in this child?
    A) Erythroblastosis fetalis due to rhesus incompatibility
    B) Erythroblastosis fetalis due to ABO blood group incompatibility
    C) Both A and B
    D) The child would not be expected to have HDN

52. A 2-year-old boy bleeds excessively from minor injuries and has previously had bleeding gums. The maternal grandfather has a bleeding disorder. The child's physical examination shows slight tenderness of his knee with fluid accumulation in the knee joint. You suspect this patient is deficient in which coagulation factor?
    A) Prothrombin activator
    B) Factor II
    C) Factor VIII
    D) Factor X

53. A patient has a congenital deficiency in factor XIII (fibrin-stabilizing factor). What would analysis of his blood reveal?
    A) Prolonged prothrombin time
    B) Prolonged whole blood clotting time
    C) Prolonged partial thromboplastin time
    D) Easily breakable clot

54. Which agent is not effective as an in vitro anticoagulant?
    A) Heparin
    B) Warfarin (Coumadin)
    C) Ethylenediamine tetraacetic acid (EDTA)
    D) Sodium citrate

55. What would most likely be used for prophylaxis of an ischemic heart attack?
    A) Heparin
    B) Warfarin
    C) Aspirin
    D) Streptokinase

56. A 63-year-old woman returned to work after a vacation in New Zealand. Several days after returning home, she awoke with swelling and pain in her right leg, which was blue. She immediately went to the emergency department, where examination showed an extensive deep vein thrombosis involving the femoral and iliac veins on the right side. After resolution of the clot, this patient will require which treatment in the future?
    A) Continual heparin infusion
    B) Warfarin
    C) Aspirin
    D) Vitamin K

57. Which coagulation pathway begins with tissue thromboplastin?
    A) Extrinsic pathway
    B) Intrinsic pathway
    C) Common pathway
    D) Fibrin stabilization

58. Which of the following causes some malnourished patients to bleed excessively when injured?
    A) Vitamin K deficiency
    B) Platelet sequestration by fatty liver
    C) Serum bilirubin that raises neutralizing thrombin
    D) Low serum protein levels that cause factor XIII problems

59. Which of the following would best explain a prolonged bleeding time test?
    A) Hemophilia A
    B) Hemophilia B
    C) Thrombocytopenia
    D) Coumadin use

60. Which of the following is appropriate therapy for a massive pulmonary embolism?
    A) Heparin
    B) Warfarin
    C) Aspirin
    D) Tissue plasminogen activator

61. What is the primary mechanism by which heparin prevents blood coagulation?
    A) Antithrombin III activation
    B) Binding and inhibition of tissue factor
    C) Binding available calcium
    D) Inhibition of platelet-activating factor

ANSWERS

1. **B)** This patient has increased production of RBCs as indicated by a markedly increased reticulocyte count in the setting of significant anemia (low number, Hb, and Hct). The RBCs being produced have a normal size (MCV = 90), and thus the patient does not have spherocytosis (small RBCs) or vitamin B_{12} deficiency (large RBCs). The normal WBC count and the increased reticulocyte count suggest that the bone marrow is functioning. The increased reticulocyte count means that a large number of RBCs are being produced. These laboratory values support an anemia due to some type of blood loss—in this case an anemia due to hemolysis.
   TMP13 p. 452

2. **B)** Carbonic anhydrase catalyzes the reaction of CO_2 with water to allow large amounts of CO_2 to be transported in blood as soluble bicarbonate ion.
   TMP13 p. 445

3. **D)** A well-trained athlete will have a slightly elevated EPO level, and the hematocrit will be elevated up to a value of 50%. A hematocrit higher than 50% suggests EPO treatment.
   TMP13 p. 448

4. **E)** Aplastic anemia is a condition in which the bone marrow has a decreased production but does not respond to EPO. Therefore, a person with aplastic anemia would have a low hematocrit and an elevated EPO level.
   TMP13 p. 452

5. **A)** People with end-stage renal disease have a decrease in EPO level due to decreased release from the diseased kidneys. As a consequence of the decreased EPO level, the hematocrit will be decreased.
   TMP13 p. 448

6. **B)** In persons with polycythemia vera, the bone marrow produces RBCs without a stimulus from EPO. The hematocrit is very high, even up to 60%. With the elevated hematocrit there is a feedback suppression of EPO, and the EPO levels are very low.
   TMP13 p. 453

7. **C)** Each hemoglobin molecule has four globin chains (in hemoglobin A, the predominant form in adults, the hemoglobin molecule includes two alpha and two beta chains). Each globin chain is associated with one heme group, containing one atom of iron. Each of the four iron atoms can bind loosely with one molecule (two atoms) of oxygen. Thus each hemoglobin molecule can transport eight oxygen atoms.
   TMP13 p. 450

8. **D)** RBC production begins in the yolk sac for the first trimester. Production in the yolk sac decreases at the beginning of the second trimester, and the liver becomes the predominate source of RBC production. During the third trimester, RBC production increases from the bone marrow and continues throughout life.
   TMP13 p. 446

9. **D)** Cell proliferation requires DNA replication, which requires an adequate supply of thymidine triphosphate. Both vitamin B_{12} and folate are needed to make thymidine triphosphate.
   TMP13 p. 449

10. **B)** This patient has polycythemia vera: increased RBCs, WBCs, and platelets. His increased hematocrit also increases the viscosity of the blood, resulting in increased afterload for the heart, which is probably the reason for his chest pain. Thus, a phlebotomy (bleeding) is needed to decrease his elevated blood cell count.
    TMP13 p. 453

11. **C)** Secondary polycythemia has developed because of exposure to low oxygen levels. She will have an increased hematocrit level, and thus an increased RBC count, but a normal WBC count. The cells are normal, so the MCV will be normal.
    TMP13 p. 453

12. **E)** This patient is anemic; Hg levels are <14 g/dl. The WBC count is normal, suggesting normal bone marrow. His RBCs are considerably larger than normal (normal MCV = 90). His lack of vegetable consumption suggests either a vitamin B_{12} or folic acid deficiency. However, the body has sufficient stores of vitamin B_{12} to last 4 to 5 years, so he does not appear to have vitamin B_{12} deficiency. The body only stores folic acid for 3 to 6 months, so not eating vegetables for 1 year would result in a folic acid deficiency.
    TMP13 pp. 449, 452

13. **B)** Mast cells express large numbers of high-affinity IgE receptors that are "pre-loaded" with IgE molecules that have been bound from plasma. When multiple IgE molecules of the appropriate specificity encounter their cognate antigen, cross-linking of the cell-bound IgE and initiation of degranulation through signals generated by the IgE receptors result.
    TMP13 p. 463

14. **B)** This African American man has sickle cell anemia, as demonstrated by his decreased hemoglobin concentration and elevated reticulocyte count. He has some

infectious/inflammatory response, as illustrated by the elevated WBC count. The high altitude was the stimulus for a hypoxic episode that caused sickling of his RBCs.

TMP13 pp. 450, 452

15. C) EPO levels increase after a decreased arterial oxygen level, with the maximum EPO production occurring within 24 hours. It takes 3 days for new reticulocytes to appear in the circulation, and after a total of 5 days from the beginning of hypoxemia, these reticulocytes will be circulating as mature erythrocytes. Because it takes 1 to 2 days for a reticulocyte to become an erythrocyte, the correct answer is 3 days until the person has an increased number of reticulocytes.

TMP13 pp. 446-448

16. C) The blood cell count values show that the patient is anemic. Her bone marrow is functioning and she has a normal platelet count, but she is generating a decreased number of abnormal RBCs. The microcytic (small), hypochromic (decreased intracellular hemoglobin) RBCs are a classic finding of iron deficiency anemia. If she had renal failure, she would be anemic with normal RBCs. People with sickle cell anemia have misshapen RBCs. Megaloblastic anemia is characterized by macrocytic (large) RBCs.

TMP13 pp. 447, 450, 452

17. C) Basophils are not phagocytic, and eosinophils are weak phagocytes. Neutrophils respond rapidly to infection or inflammation and ingest from 3 to 20 bacteria or other particles before dying. Macrophages become activated and enlarged at sites of inflammation and can ingest up to 100 bacteria per macrophage. They can extrude digested material and remain viable and active for many months.

TMP13 p. 458

18. B) The first cellular event during an inflammatory state is activation of the tissue macrophages. Invasion of neutrophils and monocytes then occur in that order. Finally, production of WBCs is increased by the bone marrow.

TMP13 p. 461

19. A) Eosinophils constitute about 2% of the total WBC count, but they are produced in large numbers in people with parasitic infections.

TMP13 p. 462

20. B) The majority of WBCs are stored in the bone marrow, waiting for an increased level of cytokines to stimulate their release into the circulation. However, trauma to bone can result in a release of WBCs into the circulation. This increase in WBC count is not primarily due to any inflammatory response, but instead is attributed to mechanical trauma and associated stress responses.

TMP13 p. 456

21. B) The WBC count of 42,000 is higher than the range usually seen as a response to infection and suggests leukemia. The patient's florid clinical presentation suggests an acute process, and findings of a normal CBC 3 months previously confirm that this patient has an acute leukemia. Granulocytes are myeloid cells, and the fact that they are in the circulation while still being immature is wholly compatible with leukemia. Thus the patient has acute myelocytic (also referred to as "myelogenous" or "myeloid") leukemia.

TMP13 p. 463

22. B) Activation of selections or integrins results in adhesion of WBCs to endothelium.

TMP13 pp. 460, 461

23. E) All WBCs originate from the bone marrow from myelocytes or lymphocyte precursors.

TMP13 p. 456

24. C) Transmigration of WBCs occurs through parts of the vasculature that have very thin walls and minimal vascular smooth muscle layers. This includes capillaries and venules.

TMP13 pp. 457, 461

25. C) For the acquired immune response, T and B lymphocytes and plasma cells, along with macrophages, are needed. Neutrophils are needed for routine infections.

TMP13 pp. 460-461

26. B) Dendritic cells are resident antigen-presenting cells, whereas eosinophils are weakly phagocytic cells whose products (e.g., major basic protein) can kill parasites without the eosinophils ingesting them. Macrophages follow the initial influx of neutrophils into an inflammatory site. Whereas neutrophils ingest a modest number of bacteria per cell before dying, macrophages persist at the site, ingesting and digesting infectious organisms and necrotic material and producing cytokines that direct tissue remodeling by fibroblasts and other cell types.

TMP13 p. 461

27. D) The presence of normal skin test reactivity, which is T cell–mediated, indicates normal function of macrophages and other antigen-presenting cells, helper T cells, and cytotoxic T cells. This information, and the reduction in antibody production, localizes the defect to the B-cell lineage.

TMP13 pp. 466, 469, 473

28. D) Patients with HIV have specific loss of T-helper cells, resulting in a loss of T-cell help for both antibody production and activation/proliferation of cytotoxic T cells. Assuming that mast cells can be appropriately stimulated (i.e., bear sufficient residual surface-bound IgE and are exposed to relevant antigen), their processes for degranulation are intact.

TMP13 p. 473

29. B) Phagocytosis of bacteria is enhanced by the presence on their surfaces of both immunoglobulin and products of the complement cascade, which in turn bind to surface receptors on phagocytes. This "tagging" of bacteria and other particles for enhanced phagocytosis is called *opsonization.*
TMP13 p. 471

30. B) Presentation of an antigen on an infected cell will result in activation of the cytotoxic T cells to kill the infected cell. Presentation of an antigen by macrophages will activate helper T cells, which can promote antibody production and support proliferation of both helper and cytotoxic T cells.
TMP13 p. 472

31. D) Helper T cells are destroyed by the AIDS virus, leaving the patient unprotected against infectious diseases.
TMP13 p. 473

32. E) Fluid leaks into the tissue due to an increase in capillary permeability.
TMP13 p. 460

33. D) Presentation of an antigen on the surface of macrophages or dendritic cells results in the activation of helper T cells. Activation of helper T cells then initiates the release of lymphokines that stimulate proliferation and activation of helper and cytotoxic T cells and B cells and the generation of antibodies.
TMP13 pp. 472-473

34. C) CD4 helper T cells recognize the MHC class II + peptide on the presenting cell. CD8 T cells recognize the MHC class I + peptide on the infected cell.
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35. B) IL-2 is secreted by helper T cells when the T cells are activated by specific antigens. IL-2 plays a specific role in the growth and proliferation of helper, cytotoxic, and suppressor T cells.
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36. D) Helper T cells are activated by the presentation of antigens on the surface of antigen-presenting cells. Helper T cells activate B cells to form antibodies, but B cells are not required for activation of helper T cells. Helper T cells help macrophages with phagocytosis but do not have the capability to phagocytize bacteria.
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37. C) Cytotoxic cells act on infected cells when the cells have the appropriate antigen located on the surface. The cytotoxic T cells are stimulated by lymphokines generated by activation of helper T cells. Cytotoxic T cells destroy an infected cell by releasing proteins that punch large holes in the membrane of the infected cells. There is no interaction between cytotoxic T cells and B cells.
TMP13 p. 473

38. A) Because the person has demonstrated allergic reactions, the initial reaction would be due to an antigen-antibody reaction and the activation of the complement system. Influx of neutrophils, activation of T-helper cells, and sensitized lymphocytes would take some time.
TMP13 p. 475

39. D) Activation of the complement system results in a series of actions, including opsonization and phagocytosis by neutrophils, lysis of bacteria, agglutination of organisms, activation of basophils and mast cells, and chemotaxis. Fragment C5a of the complement system causes chemotaxis of neutrophils and macrophages.
TMP13 p. 471

40. D) HDN occurs when an Rh-negative mother gives birth to a second Rh-positive child. Therefore, the father must be Rh positive. The mother becomes sensitized to the Rh antigens after the birth of the first Rh-positive child. HDN is prevented by treating the mother with antibodies against Rh antigen after the birth of each Rh-positive child. This treatment will destroy all fetal RBCs in the mother and prevent the mother from being sensitized to the Rh antigen. A transfusion of the first child after the birth will not accomplish anything because the mother has been exposed to the Rh-positive antigen during the birth process.
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41. D) The recipient blood has the larger amount of plasma and thus antibodies. These antibodies will act on the donor RBCs. The donor's plasma will be diluted and have minimal effect on the recipient's RBCs. With any antigen–antibody transfusion reaction a rapid breakdown of RBCs occurs, releasing hemoglobin into the plasma, which can cause rapid acute renal shutdown. Transfusion of Rh-positive blood will only result in a transfusion reaction if the Rh-negative person has previously undergone a transfusion or been exposed to Rh-positive antibodies. Type AB Rh-positive people have no antibodies to the A, B, or Rh(D) antigens in their plasma, so they can receive any blood type.
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42. D) Each parent needs only a single allele for either the A or B antigen or the Rh(D) antigen to express these antigens on their blood cells and other cell types. Thus, if each parent also carries an allele for blood type O, as well as a null allele for the Rh(D) antigen, then the child can be homozygous for the recessive O allele and the Rh(D)-negative allele.
TMP13 pp. 478-479

43. D) The appropriate treatment is repetitive removal of Rh-positive blood, replacing it with Rh-negative blood (an exchange of about 400 milliliters over 90 minutes). This treatment may be performed several times over

a few weeks. Maternal antibodies disappear over 1 to 2 months, so the newborn's endogenous Rh-positive cells cease to be a target. Exchange transfusions can actually be initiated in utero when there is evidence of an active immune reaction against the fetus's blood cells.

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44. C) Allograft rejection occurs primarily through the actions of cytotoxic T cells. T-helper cells promote this reaction but are not the effector cells. Both macrophages and dendritic cells may present antigen that promotes the immune response, but the key effector cells are cytotoxic T cells.

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45. B) Transfusion of Rh-negative blood into an Rh-positive person with the same ABO type will not result in any reaction. Type A blood has A antigen on the surface and type B antibodies. Type B blood has B antigens and A antibodies. Therefore, transfusing A blood into a person with type B blood will cause the A antibodies in the type B person to react with the donor blood.

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46. D) In any patient, transfusion of O-type packed cells will minimize a transfusion reaction because the antibodies will be removed with the plasma removal. Matching the Rh factor will also minimize transfusion reaction. Therefore, in a patient with type B-positive blood, a B-positive transfusion or an O-positive transfusion will elicit no transfusion reaction.

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47. C) Hemophilia is due to a genetic loss of clotting factor VIII. Most clotting factors are formed in the liver. Correction of the problem with a vitamin K injection implies that the liver is working fine and that the patient does not have hepatitis. Vitamin K is a fat-soluble vitamin that is absorbed from the intestine along with fats. Bile secreted by the gallbladder is required for the absorption of fats. If the patient is deficient in vitamin K, then clotting deficiency can be corrected by an injection of vitamin K. Antithrombin III has no relationship to factor IX.

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48. D) Type O RBCs are considered to be universal donor blood. Reactions occur between the recipient's antibody and donor antigen as shown in the following table.

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Donor	Donor Antigen	Recipient	Recipient Antibody	Reaction
O-negative	None	AB-positive	None	None
A-positive	A, Rh	A-negative	B	None
AB-positive	A, B, Rh	AB-positive	None	None
A-positive	A, Rh	O-positive	A, B	A (antigen) and A (antibody)

49. D) Unmatched donor HLA antigens of both classes are recognized as foreign by recipient T cells. In addition, blood group (ABO) antigens are expressed on the cells of solid organs and can lead to strong organ rejection.

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50. C) Antibiotic treatment for pneumonia can kill flora in the gastrointestinal tract that are critical for the production of vitamin K. Production of several active clotting factors (prothrombin and factors VII, IX, and X) has been suppressed in this patient by warfarin inhibition of VKOR c1, which normally reduces vitamin K so that it can activate the listed clotting factors. Further reduction of vitamin K by the death of critical gut flora has produced excessive anticoagulation and resulted in bleeding in this patient. Fresh frozen plasma is infused to provide active clotting factors immediately, and vitamin K is provided to promote endogenous production of active clotting factors. Both are needed in the setting of acute bleeding.

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51. D) HDN occurs when the mother is Rh negative and the father is Rh positive, resulting in an Rh-positive child. Because the child is O negative and the father is Rh negative, HDN would not be expected to develop.

TMP13 pp. 478-479

52. C) A young man with a bleeding disorder and a history of bleeding disorders in the males of his family would lead one to suspect hemophilia A, a deficiency of factor VIII. The physical examination suggests bleeding into the knee joint, which is frequently seen in hemophilia A.

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53. D) Fibrin monomers polymerize to form a clot. Creation of a strong clot requires the presence of fibrin-stabilizing factor that is released from platelets within the clot. The other clotting tests determine the activation of extrinsic and intrinsic pathways or number of platelets.

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54. B) Warfarin interferes with endogenous production of active clotting factors but does not affect their function once they are present, as in normal plasma. Heparin activates antithrombin III to produce anticoagulation either in vitro or in vivo. Both EDTA and sodium citrate bind calcium, which is necessary for clotting to proceed.

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55. C) Heparin is used for the prevention of a clot, but it must be infused. Heparin prevents formation of clots by binding to antithrombin III, resulting in the inactivation of thrombin. Warfarin is used to inhibit the formation of vitamin K clotting factors. Aspirin is used to prevent activation of platelets. Activation of plate-

lets after exposure to an atherosclerotic plaque and the formation of a platelet plug will impede blood flow and result in an ischemic heart attack. Streptokinase (or, alternatively, tissue plasminogen activator) is used to break down an already formed clot, which is appropriate therapy for a pulmonary embolus.

TMP13 pp. 491-492

56. B) This clot is due to stasis of blood flow in the patient's venous circulation. Heparin is used for the prevention of a clot, but it must be infused. This anticoagulation occurs by heparin binding to antithrombin III, with subsequent inactivation of thrombin. A continuous heparin drip is impractical. Warfarin is used to inhibit the formation of vitamin K clotting factors and would prevent the formation of any clot. Aspirin is used to prevent activation of platelets. The current clot is not due to activation of platelets. Vitamin K would be used to restore clotting factors that may be decreased after warfarin treatment. This patient has sufficient clotting factors, as evidenced by her venous clot.

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57. A) The extrinsic pathway begins with the release of tissue thromboplastin in response to vascular injury or contact between traumatized extravascular tissue and blood. Tissue thromboplastin is composed of phospholipids from the membranes of tissue.

TMP13 p. 487

58. A) Several clotting factors that are formed in the liver require vitamin K to be functional. Vitamin K is a fat-soluble vitamin, and absorption is dependent on adequate fat digestion and absorption. Therefore, any state of malnutrition could have decreased fat absorption and result in decreased vitamin K absorption and decreased synthesis of clotting factors.

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59. C) Three major tests are used to determine coagulation defects. Prothrombin time is used to test the extrinsic pathway and is based on the time required for the formation of a clot after the addition of tissue thromboplastin. Bleeding time after a small cut is used to test for several clotting factors but is especially prolonged by a lack of platelets.

TMP13 pp. 492-493

60. D) Heparin is used for the prevention of a clot. Heparin binds to antithrombin III, resulting in the inactivation of thrombin. Warfarin is used to inhibit the formation of vitamin K clotting factors. Aspirin is used to prevent activation of platelets. Tissue plasminogen activator is used to break down an already formed clot, which is appropriate therapy for a pulmonary embolus.

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61. A) The primary function of heparin is to bind to and activate antithrombin III.

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