Blood cells, immunity, and blood coagulation

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

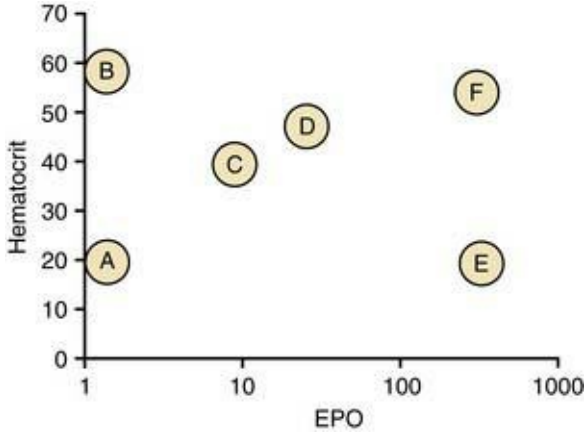
Test	Normal Values
Bleeding time (template)	2–7 minutes
Erythrocyte count	Male: 4.3–5.9 million/μl^3
	Female: 3.5–5.5 million/μl^3
Hematocrit	Male: 41–53%
	Female: 36–46%
Hemoglobin, blood	Male: 13.5–17.5 g/dL
	Female: 12.0–16.0 g/dL
Mean corpuscular hemoglobin	25.4–34.6 pg/cell
Mean corpuscular hemoglobin concentration	31–36% Hb/cell
Mean corpuscular volume	80–100 fl
Reticulocyte count	0.5–1.5% of red 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. During the second trimester of pregnancy, where is the predominant site of red blood cell production?

A) Yolk sac
B) Bone marrow
C) Lymph nodes
D) Liver

2. Following a blood donation, red cell production begins to increase in
A) 30 minutes
B) 24 hours
C) 2 days
D) 5 days
E) 2 weeks

Questions 3–6
Which points in the following graph 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. A 62-year-old female arrives for her annual physical. She complains of itching in her hands along with headaches and vertigo. A routine complete blood count (CBC) shows red blood cells (RBCs) of 8.2 million/µl, white blood cells (WBCs) 37,000/µl, and platelets 640,000/µl. Her erythropoietin levels are lower than normal. The primary diagnosis would be
A) thrombocytopenia
B) relative polycythemia
C) secondary polycythemia
D) polycythemia vera
E) myeloid leukemia

8. A 40-year-old woman visits the clinic complaining of fatigue. She had recently been treated for an infection. Her laboratory values are RBC $1.8 \times 10^6/\mu l$, Hb 5.2 g/dL, hematocrit (Hct) 15, WBC $7.6 \times 10^3/\mu l$, 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

9. Which of the following would describe the condition in a patient with aplastic anemia?

	Hct	Blood Hemoglobin	MCV	EPO
A)	↔	↔	↔	↔
B)	↔	↓	↓	↑
C)	↓	↓	↔	↑
D)	↓	↔	↔	↔
E)	↔	↔	↑	↑
F)	↓	↓	↑	↔
G)	↓	↔	↔	↑

10. 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, leukocyte count is $10,000/\mu l^3$, and MCV is 122. Which of the following is the most likely diagnosis?

A) Acute blood loss
B) Sickle cell
C) Aplastic anemia
D) Hemolytic anemia
E) Folic acid deficiency

11. A 24-year-old African-American man comes to the emergency room 3 hr 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:

Hemoglobin	11 gm/dl
Leukocyte count	22,000/μl^3
Reticulocyte count	25%

What is the diagnosis of this patient?

A) Acute blood loss
B) Sickle cell anemia
C) Anemia of chronic disease
D) End-stage renal disease

12. A 62-year-old man complains of headaches, visual difficulties, and chest pains. His examination shows a red complexion and a large spleen. His complete blood count follows: hematocrit, 58%, WBC 13,300/µl, and platelets 600,000/µl. His arterial oxygen saturation is 97% on room air. Which of the following would you recommend as a treatment?

A) Chemotherapy
B) Phlebotomy
C) Iron supplement
D) Inhaled oxygen therapy

13. A 45-year-old woman developed fatigue in July and had blood counts that were reported to be normal. She was hospitalized because of a very severe headache in December, and was found to have a blood pressure of 175/90. Her laboratory values were as follows: hemoglobin (8.3 g/dL), RBC count (2.2×10^6/µl), Hct (23%), MCV (89 fL), WBCs (5100/µl), platelets (262×10^3/µl), and reticulocyte count 0.8%. What is the diagnosis for this patient?

A) Folic acid deficiency
B) Iron deficiency
C) Hemolytic anemia
D) End-stage renal disease

14. A 38-year-old healthy female comes to you for a routine visit. She has spent the last 2 months hiking through the Himalayas and climbed to the base camp of Mount Everest. Which of the following would you expect to see on her CBC (complete blood count)?

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

15. A patient presents to your office complaining of extreme fatigue and shortness of breath on exertion

that has gradually worsened over the past 2 weeks. On physical examination, you observe a well-nourished woman who appears comfortable but somewhat short of breath. Her vital signs include a pulse of 120, 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 Hgb 7 g/dL, Hct 20%, RBC count $2 \times 10^6/\mu l$, platelet count of 400,000/µl. On a peripheral smear, her RBCs are microcytic and hypochromic. What would be your diagnosis of this patient?

A) Aplastic anemia
B) Renal failure
C) Iron deficiency anemia
D) Sickle cell anemia
E) Megaloblastic anemia

16. After a person is placed in an atmosphere with low oxygen, how long does it take before there are increased numbers of reticulocytes?

A) 6 hours
B) 12 hours
C) 3 days
D) 5 days
E) 2 weeks

17. Over the past 12 weeks, a 75-year-old man with a moderate aortic stenosis has developed shortness of breath and chest pains during exertion. He appears pale. Test of his stool for blood is positive. Laboratory studies show the following: hemoglobin 7.2 g/dL, and mean corpuscular volume 75. A blood smear shows microcytic, hypochromic erythrocytes. Which of the following is the most likely diagnosis?

A) Vitamin B_{12} deficiency
B) Autoimmune hemolytic anemia
C) Folate deficiency anemia
D) Iron deficiency anemia

18. A 24-year-old man came into the ER with a broken leg. A blood test was ordered and his WBC count was $22 \times 10^3/\mu l$. Five hours later, a second blood test resulted in values of $7 \times 10^3/\mu l$. What is the cause of the increased WBC count with the first test?

A) Increased production of WBC by the bone marrow
B) Shift of WBCs from the marginated pool to the circulating pool
C) Decreased destruction of WBCs
D) Increased production of selectins

19. Adhesion of white blood cells 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 venous side of the circulation

20. During an inflammatory response, which is the correct order for 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

21. In a normal healthy person, which of the following blood components has the shortest life span?

A) Macrophages
B) Memory T cells
C) Erythrocytes
D) Memory B lymphocytes

22. A 45-year-old man presents to the emergency room with a 2-week history of diarrhea that has gotten progressively worse over the last 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 WBCs would have an elevated number?

A) Eosinophils
B) Neutrophils
C) T lymphocytes
D) B lymphocytes
E) Monocytes

23. An 8-year-old male is frequently coming to the clinic for persistent skin infections that do not heal within a normal time frame. He had a normal recovery from the measles. Checking his antibodies following immunizations yielded normal antibody responses. A defect in which of the following cells would most like be the cause of the continual infections?

A) B lymphocytes
B) Plasma cells
C) Neutrophils
D) Macrophages
E) CD4 T lymphocytes

24. Where does the transmigration of WBCs occur in response to infectious agents?

A) Arterioles
B) Lymphatic ducts
C) Venules
D) Inflamed arteries

25. A 65-year-old alcoholic developed chest pain and cough with an expectoration of sputum. A blood sample revealed that his white blood cell count was 42,000/μl. What is the origin of these WBCs?

A) Pulmonary alveoli
B) Bronchioles
C) Bronchi
D) Trachea
E) Bone marrow

26. A 26-year-old man received a paper cut. What substance is the major cause of pain of this acute inflammatory response?

A) Platelet-activating factor (PAF)
B) Bradykinin
C) Interleukin-1
D) Tumor necrosis factor (TNF)

27. A patient visits his dentist, who notices a sore on the patient's lip. The sore was unusual in that there was no pain or drainage from the sore. The patient was subsequently admitted to the hospital with a violent shaking chill. His lab values were Hct 30%, platelets 400,000/µl, WBC 4200/µl, 68% lymphocytes, and 20% neutrophils. What is the diagnosis of this patient?

A) A mild, nontreatable, infection
B) Agranulocytosis
C) Aplastic anemia
D) Acute leukemia

28. What occurs following activation of basophils?

A) Decreased diapedesis of neutrophils
B) Decreased ameboid motion
C) Contraction of blood vessels
D) Increased capillary permeability

29. Fluid exudation into the tissue in the acute inflammatory reaction is due to

A) decreased blood pressure
B) decreased protein in the interstitium
C) obstruction of the lymph vessels
D) increased clotting factors
E) increased vascular permeability

30. Which of the following applies to AIDS patients?

A) Able to generate a normal antibody response
B) Increased helper T cells
C) Increased secretion of interleukins
D) Decrease in helper T cells

31. Presentation of antigen on MHC-I by a cell will result in

A) generation of antibodies
B) activation of cytotoxic T cells
C) increase in phagocytosis
D) release of histamine by mast cells

32. What is the term for adhesion of an invading microbe with IgG and complement to facilitate recognition?

A) Chemokinesis
B) Opsonization
C) Phagolysosome fusion

D) Signal transduction

33. Interleukin-2 (IL-2) is an important molecule in the immune response. What is the function of IL-2?
A) Binds to and presents antigen
B) Stimulates proliferation of cytotoxic T cells
C) Kills virus-infected cells
D) Is required for replication of helper T cells

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

35. What will occur following 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

36. Activation of the complement system results in which of the following actions?
A) Binding of the invading microbe with IgG
B) Inactivation of eosinophils
C) Decreased tissue levels of complement
D) Generation of chemotaxic substances

37. A 9-year-old female 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 she develops a focal redness and a 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

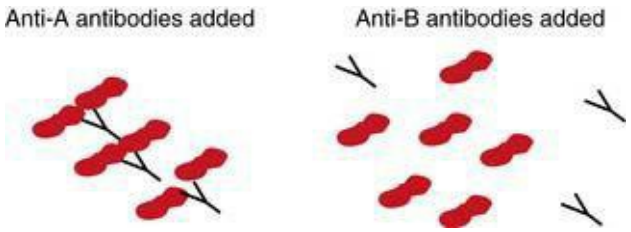
38. Which of the following applies to cytotoxic T cells?
A) Cytotoxic T cells require the presence of a competent B-lymphocyte system
B) Cytotoxic T cells require the presence of a competent suppressor T-lymphocyte system
C) Cytotoxic T cells are activated by the presentation of antigen by an infected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

39. Helper T cells
A) are activated by the presentation of antigen by an infected cell
B) require the presence of a competent B-cell system
C) destroy bacteria by phagocytosis
D) are activated by the presentation of antigen by macrophage or dendritic cells

40. Which of the following transfusions will result in an immediate transfusion reaction?
A) O Rh− whole blood to an O Rh+ patient
B) A Rh− whole blood to a B Rh− patient
C) AB Rh− whole blood to an AB Rh+ patient
D) B Rh− whole blood to an B Rh− patient

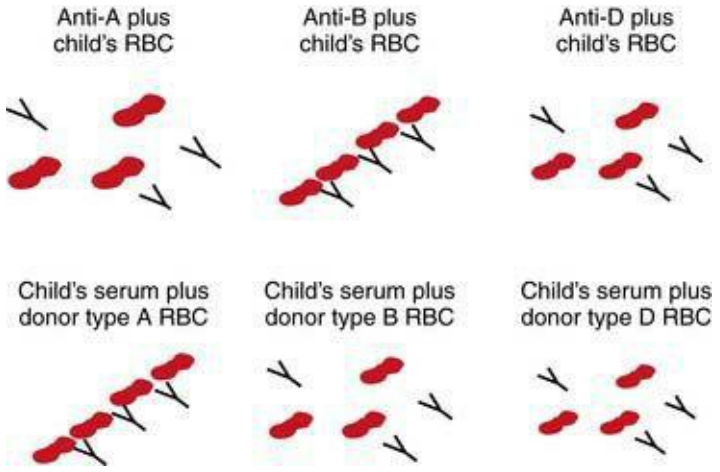
41. Which of the following is a TRUE statement?
A) In a transfusion reaction, there is agglutination of the recipient blood
B) Shutdown of the kidneys following a transfusion reaction occurs slowly
C) Blood transfusion of Rh+ blood into any Rh− recipient will result in an immediate transfusion reaction
D) A person with type AB blood is considered to be a universal recipient

42. Which blood type is depicted in the following figure?



A) A
B) B
C) O
D) AB

43. A couple requests blood typing of their 2-year-old child (father AB, Rh-negative; mother B, Rh-negative). Results of hemagglutination assays of the child's blood are shown in the next figure. Which of the following conclusions concerning the child's parentage is valid?



A) The child could be the natural offspring of this couple
B) The mother could be the natural mother, but the father could not be the natural father

C) The father could be the natural father, but the mother could not be the natural mother
D) Neither the father nor the mother could be the natural parents

44. A 21-year-old female, blood type B, is undergoing surgery. Her platelet count is 75,000/μl. She will need platelet infusions before and during surgery. Which of the following blood types would be used to collect platelets that are compatible with the patient?
A) Type A only
B) Type B only
C) Type O only
D) Types B and O
E) Types A and B
F) Types A and B only
G) Types A, B, and AB only

45. Which of the following is TRUE concerning erythroblastosis fetalis (hemolytic disease of the newborn, HDN)?
A) This occurs when a Rh+ mother has an Rh− child
B) This 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 has to be Rh+

46. Which of the following will result in a transfusion reaction? Assume that the patient has never had a transfusion.
A) Type O Rh− packed cells to an AB Rh+ patient
B) Type A Rh+ packed cells to an A Rh− patient
C) Type AB Rh+ packed cells to an AB Rh+ patient
D) Type A Rh+ packed cells to an O Rh+ patient

47. A mother of blood type A+ who has always been perfectly healthy just delivered her second child. The father is of blood group O−. Knowing that the child is of blood group O− (O, Rh−), what would you expect to find in this child?
A) The child will suffer from erythroblastosis fetalis due to rhesus incompatibility
B) The child will suffer from erythroblastosis fetalis due to ABO blood group incompatibility
C) The child will suffer from both A and B
D) The child has no chance of developing HDN

48. Which of the following blood units carries the least risks for inducing an immediate transfusion reaction into a B+ (B, rhesus positive) recipient?
A) Whole blood A+
B) Whole blood O+
C) Whole blood AB+
D) Packed red cells O+
E) Packed red cells AB−

49. A pregnant woman comes in for a visit. She is AB Rh− and her husband is A Rh+. This is her first child. What should be done at this time?

A) Nothing
B) Administer anti-D immunoglobulin to the mother at this time
C) Administer anti-D immunoglobulin to the mother after delivery
D) Administer anti-D immunoglobulin to the child after delivery
E) Administer anti-D immunoglobulin to the child if the child is Rh+

50. What is the proper pathway for the extrinsic clotting pathway?
A) Contact of blood with collagen, formation of prothrombin activator, conversion of prothrombin into thrombin, conversion of fibrinogen into fibrin threads
B) Tissue trauma, formation of prothrombin activator, conversion of prothrombin into thrombin, conversion of fibrinogen into fibrin threads
C) Activation of platelets, formation of prothrombin activator, conversion of prothrombin into thrombin, conversion of fibrinogen into fibrin threads
D) Trauma to the blood, formation of prothrombin activator, conversion of prothrombin into thrombin, conversion of fibrinogen into fibrin threads

51. 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

52. A patient suffers from 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

53. A 2-year-old boy bruises easily and has previously had bleeding gums. The maternal grandfather has a bleeding disorder. His physical examination shows several small bruises on the legs. Of which coagulation factor would you suspect this patient to be deficient?
A) Prothrombin activator
B) Factor II
C) Factor VIII
D) Factor X

54. An 11-year-old premenstrual female presents with a painful knee after mild trauma. Upon further evaluation you observe soft tissue bruises. The child is an orphan and there is no family history. The foster mother reports no other problems. The aPTT is prolonged and the PT is normal. A complete hematologic workup would yield
A) decreased plasma Ca^{2+}
B) elevated plasmin
C) lack of factor VIII
D) decreased platelet number

55. The coagulation pathway that begins with tissue thromboplastin is
A) extrinsic pathway
B) intrinsic pathway
C) common pathway
D) fibrin stabilization

56. A 63-year-old woman returned to work following a vacation in New Zealand. Several days after returning home, she awoke with swelling and pain in her right leg and her leg was blue. She went immediately to the emergency room where an examination showed an extensive deep vein thrombosis involving the femoral and iliac veins on the right side. Following 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 of the following would most likely be used for prophylaxis of transient ischemic heart attack?
A) Heparin
B) Warfarin
C) Aspirin
D) Streptokinase

58. Which of the following would be appropriate therapy for massive pulmonary embolism?
A) Heparin
B) Warfarin
C) Aspirin
D) Tissue plasminogen activator

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

60. Why do some malnourished patients bleed excessively when injured?
A) Vitamin K deficiency
B) Platelet sequestration by fatty liver
C) Serum bilirubin raises neutralizing thrombin
D) Low serum-protein levels cause factor XIII problems

61. A teenaged boy with numerous nosebleeds was referred to a physician for evaluation prior to a minor surgery. His prothrombin time (PT) was 11 sec (11–15 sec normal), partial thromboplastin time (PTT) was 58 sec (25–40 sec normal), and bleeding time was 6.5 min (2–7 min normal). Which of the following is most likely abnormal in this young man?
A) Decreased platelet number

B) Defective platelets
C) Intrinsic pathway
D) Extrinsic pathway
E) Production of clotting factors by the liver

Answers

1.D) Red blood cell 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 red cell production. During the third trimester red cell production increases from the bone marrow and continues throughout life.
TMP12 414

2.B) Red cell production increases rapidly within 24 hours; however, new red cells do appear in the blood for 5 days.
TMP12 416

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.
TMP12 416

4.E) Aplastic anemia is a condition in which the bone marrow has a decreased production but does not respond to erythropoietin. Therefore, a person with aplastic anemia would have a low hematocrit and an elevated erythropoietin level.
TMP12 420

5.A) With end-stage renal disease there is a decrease in erythropoietin level due to decreased release from the diseased kidneys. As a consequence of the decreased erythropoietin level, the hematocrit will be decreased.
TMP12 416

6.B) With polycythemia vera the bone marrow produces red blood cells without a stimulus from erythropoietin. The hematocrit is very high, even up to 60%. With the elevated hematocrit there is a feedback suppression of erythropoietin and the erythropoietin levels are very low.
TMP12 421

7.D) The increase in RBC, WBC, and platelets suggests that the patient is suffering from polycythemia vera. Renal disease would result in a low EPO level, but the RBC count would be low. Myeloid leukemia would result in an increase in WBCs, with no increase in RBCs. Secondary polycythemia would have an elevated EPO level. Relative is due to dehydration.
TMP12 421

8.B) This patient has decreased production of red blood cells as confirmed by the anemia (low number, Hb, and Hct), yet the red blood cells being produced have a normal size, MCV = 90. Therefore, the patient does not have spherocytosis (small red cells) or vitamin B_{12} deficiency (large red cells). 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 red cells are being produced. These laboratory

values support an anemia due to some type of blood loss; in this case an anemia due to hemolysis.
TMP12 420

9.C) With aplastic anemia the person has minimal or no red cell production. The Hct and hemoglobin would be low, the MCV would be normal (normal red cells just low production), and an elevated EPO level.
TMP12 420

10.E) This patient is anemic: Hg < 14 g/dL. White count is normal, suggesting a normal bone marrow. His red cells 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 1 year of not eating vegetables would result in a folic acid deficiency.
TMP12 417, 420

11.B) This African-American man has anemia as seen by his decreased hemoglobin concentration and his elevated reticulocyte count. He has some infectious/inflammatory response as seen with the elevated white count. The high altitude was the stimulus for a hypoxic episode that caused sickling of his red cells. This patient has sickle cell anemia.
TMP12 418, 420

12.B) This patient has polycythemia vera: increased RBCs, WBCs, and platelets. His increased Hct also increases the viscosity of the blood resulting in increased afterload for the heart. This is probably the reason for his chest pain. Thus, a phlebotomy (bleeding) is needed to decrease his elevated blood count.
TMP12 421

13.D) This patient is anemic, but the RBCs being produced are normal (note normal MCV). The overall production of the RBCs is decreased (reticulocyte count is low). WBCs and platelets are normal, suggesting a normal bone marrow. Folic acid and iron deficiency anemia would result in a lower RBC MCV. Hemolytic anemia would result in an increase reticulocyte count. The elevated blood pressure provides evidence of renal disease. This patient has end-stage renal disease and decreased erythropoietin production.
TMP12 416

14.C) She has developed secondary polycythemia due to exposure to low oxygen. She will have increased HCT, and thus increased RBC count, but normal WBC count. The cells are normal so the MCV will be normal.
TMP12 421

15.C) The blood count values show that the patient is anemic. Her bone marrow is functioning and she has a normal platelet count, but is generating a decreased number of abnormal RBCs. The microcytic (small), hypochromic (decreased intracellular hemoglobin) is a classic description of iron deficiency anemia. With renal failure the patient would be anemic with normal RBCs. Sickle cell anemia has misshapen RBCs. Megaloblastic anemia is characterized by macrocytic (large) RBCs.
TMP12 418

16.C) Erythropoietin levels increase following a decreased arterial oxygen level with the maximum erythropoietin production occurring within 24 hours. It takes 5 days for the production of new erythrocytes. However, since it takes 1–2 days for a reticulocyte to become an erythrocyte, the correct answer is 3 days until there are an increased number of reticulocytes.
TMP12 414-416

17.D) This patient is anemic and has low hemoglobin with small red cells. Vitamin B_{12} and folic acid deficiency will result in macrocytic red blood cells. His WBC and platelet counts are normal, suggesting a normal bone marrow. The positive stool shows a gastrointestinal blood loss. A person can be anemic from a blood loss and have normal-sized RBCs as long as there is enough iron in the body. The microcytic and hypochromic RBCs are classic signs of iron deficient anemia.
TMP12 417-417

18.B) The majority of WBCs are stored in the bone marrow, waiting for an increased level of cytokines to stimulate the release from the bone marrow. However, trauma to bone can result in a release of WBCs into the circulation. This increase in WBC count is not due to any inflammatory response, but instead to mechanical trauma.
TMP12 424

19.B) Activation of selections or integrins results in adhesion of white cells to endothelium.
TMP12 425, 429

20.B) The first cellular event during an inflammatory state is activation of the tissue macrophages. Then there is invasion of neutrophils and monocytes in that order, and finally there is an increase in production of WBCs by the bone marrow.
TMP12 428

21.C) Macrophages last for many years. T- and B-memory cells will last the life of the patient. Erythrocytes last about 120 days and then are destroyed during passage through the spleen.
TMP12 424

22.A) Eosinophils constitute about 2% of the total WBC count, but are produced in large numbers in people with parasitic infections.
TMP12 430

23.C) For the acquired immune response, T and B lymphocytes, and plasma cells, along with macrophages are needed. Basophils are not required to fight mild infections. Neutrophils are needed for routine infections.
TMP12 428-429

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.
TMP12 425, 429

25.E) All white blood cells originate from the bone marrow from myelocytes or lymphocytes.
TMP12 424

26.B) There are several factors that can cause pain and initiate pain. These include histamine, bradykinin, and prostaglandins. PAF activates platelets during the clotting process. Interleukin and TNF are factors involved in the inflammatory response and control of macrophages.
TMP12 428

27.B) The patient has a slightly decreased red cell count and normal platelet count. This would suggest that the bone marrow is working properly. His white count is within the normal range, but the percentage of cells is not normal. He should have 60% neutrophils. The 66% lymphocytes (30% normal value) would suggest that the patient has an acute leukemia.
TMP12 431

28.D) Basophils release heparin, histamine, and a series of activating factors. The histamine acts to increase capillary permeability while the heparin prevents clotting. Substances released from basophils also attract neutrophils and increase capillary permeability.
TMP12 431

29.E) Fluid leaks into the tissue due to an increase in capillary permeability.
TMP12 428

30.D) Helper T cells are destroyed by the AIDS virus, leaving the patient unprotected against infectious diseases.
TMP12 440

31.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, leading to antibody formation.
TMP12 441

32.B) One of the products of the complement cascade activates phagocytosis of the bacteria to which the antigen-antibody complex is attached. This is called opsonization.
TMP12 439

33.B) Interleukin-2 (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 both cytotoxic and suppressor T cells.
TMP12 440–441

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.
TMP12 440

35.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 cytotoxic T-cell activation along with activation of B cells and the generation of antibodies.
TMP12 440–441

36.D) Activation of the complement system results in a series of actions. These include 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.

TMP12 439

37.A) Since 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.

TMP12 443

38.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.

TMP12 441

39.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.

TMP12 440–441

40.B) Transfusion of Rh− blood into a Rh+ 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.

TMP12 445–448

41.D) The recipient blood has the larger amount of plasma and thus antibodies. These antibodies will act on the donor red blood cells. The donor's plasma will be diluted and have minimal effect on the recipient's red blood cells. With any antigen–antibody transfusion reaction there is a rapid breakdown of red blood cells, releasing hemoglobin into the plasma, which can cause rapid acute renal shutdown. Transfusion of Rh+ blood will only result in a transfusion reaction if the Rh− person has previously been transfused or exposed to Rh+ antibodies. A type AB person has no AB antibodies in their plasma, so they can receive any blood type.

TMP12 448

42.A) There is an antigen and antibody reaction between the anti-A antibodies and the red cells. There is no reaction between the anti-B antibodies and the red cells. Therefore the red cells have the A antigen and the cells must be type A.

TMP12 446-447

43.A) There is no antigen and antibody reaction between the anti-B antibodies and the red cells. There is a reaction between the anti-B antibodies and the red cells. Therefore the red cells have the B antigen and must be type B. There is no antigen and antibody reaction between the anti-D antibodies and the red

cells. Therefore the red cells must be Rh-negative. The child is blood type B−. Since father is AB− and the mother is B−, the child could be B−.

TMP12 446–447

44.B) Since the plasma contains antibodies the wrong plasma could contain antibodies against the B antigen. Therefore, he could receive B plasma (containing anti-A antibodies) or AB (containing neither anti-A or anti-B antibodies.)

TMP12 448

45.D) HDN occurs when an Rh− mother gives birth to a second Rh+ child. Therefore, the father has to be Rh+. The mother becomes sensitized to the Rh antigens following the birth of the first Rh+ child. HDN is prevented by treating the mother with antibodies against Rh antigen after the birth of each Rh+ child. This will destroy all fetal RBCs in the mother and prevent the mother from being sensitized to the Rh antigen. A complete blood transfusion of the mother would be required to prevent the formation of Rh antibodies, but this is impractical. A transfusion of the first child after the birth will not accomplish anything as the mother has been exposed to the Rh+ antigen during the birth process.

TMP12 447–448

46.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.

Donor	Donor Antigen	Recipient	Recipient Antibody	Reaction
O−	None	AB+	None	None
A+	A, Rh	A−	B	None
AB+	A, B, Rh	AB+	None	None
A+	A, Rh	O+	A, B	A (antigen) and A (antibody)

TMP12 445–447

47.D) HDN occurs when the mother is Rh−, the father is Rh+, resulting in an Rh− child. Since the child is O− and the father is Rh−, there is no chance of HDN.

TMP12 447-448

48.D) In any patient, transfusion of O-type packed cells will minimize a transfusion reaction since the antibodies will be removed with the plasma removal. If the Rh factor is matched, then this will also minimize transfusion reaction. Therefore, in a B+ patient, a B+ transfusion or an O+ transfusion will elicit no transfusion reaction.

TMP12 445–448

49.A) An Rh− mother will generate antibodies to the Rh+ red blood cells after the birth of the first child that is Rh+. In the scenario presented, the mother has not been exposed to Rh+ RBCs so she has not developed antibodies. However, after the birth of this child, and if the child is found to be Rh+, then anti-

D immunoglobulin should be administered to the mother to destroy any fetal RBCs to which she has been exposed and to prevent her from forming antibodies to the Rh+ (D) antigen.

TMP12 447-448

50.B) The extrinsic pathway involves damage to the tissue, then the subsequent formation of prothrombin activator. Tissue trauma results in the release of tissue factor or tissue thromboplastin, which functions as a proteolytic enzyme. Tissue factor binding with factor VII results in an activation of factor X. There is a subsequent activation of prothrombin activator, conversion of prothrombin to thrombin, then the conversion of fibrinogen into fibrin threads. Activation of the extrinsic pathway is very fast because of the small number of enzymatic reactions.

TMP12 453–455

51.C) Hemophilia is due to a genetic loss of clotting factor VIII. Most clotting factors are formed in the liver. If a vitamin K injection will correct the problem, this implies that the liver is working fine, and that the patient does not have hepatitis. Vitamin K is a fat-soluble vitamin and 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 II has no relationship to factor IX.

TMP12 457–458

52.D) Fibrin monomers polymerize to form a clot. To make 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.

TMP12 452, 454, 460–461

53.C) A young man with bleeding disorders and a history of bleeding disorders in the males of his family would lead one to suspect hemophilia A, a deficiency of factor VIII.

TMP12 458

54.D) Factor VIII is classical hemophilia which occurs in males. Plasma Ca^{2+} does not change. Plasminogen breaks up clots. The bruises suggest that there is abnormal platelet number or function.

TMP12 457-458, 460–461

55.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.

TMP12 455

56.B) This clot is due to stasis of blood flow in her venous circulation. Heparin is used for the prevention of a clot, but has to be infused. This anticoagulation occurs by heparin binding to antithrombin III and the 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 will 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.

TMP12 459–460

57.C) Heparin is used for the prevention of a clot, but has to be infused. This occurs by binding to antithrombin III and the subsequent 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 platelets following exposure to an atherosclerotic plaque and the formation of a platelet plug will impede blood flow and result in an ischemic heart attack. Streptokinase is used to break down an already formed clot, which is appropriate therapy for a pulmonary embolus.

TMP12 459–460

58.D) Heparin is used for the prevention of a clot. This occurs by binding to antithrombin III and the subsequent inactivation of thrombin. Warfarin is used to inhibit the formation of vitamin K clotting factors. Aspirin is used to prevent activation of platelets. Streptokinase is used to break down an already formed clot, which is appropriate therapy for a pulmonary embolus.

TMP12 459

59.C) There are three major tests 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 following the addition of tissue thromboplastin. Bleeding time following a small cut is used to test for several clotting factors, but is especially prolonged by a lack of platelets.

TMP12 460

60.A) The clotting factors are formed in the liver and require vitamin K. Vitamin K is a fat-soluble vitamin and absorption is dependent on adequate fat digestion and absorption. Therefore, any state of malnutrition would have a decreased fat absorption, and results in decreased vitamin K absorption and decreased synthesis of clotting factors.

TMP12 457–458

61.C) The prothrombin time, test of extrinsic pathway, is the time required for clot formation following addition of tissue thromboplastin. This is normal so no problem with extrinsic. Partial thromboplastin time is a test of the intrinsic pathway. This is longer than normal so there is a problem with the intrinsic pathway. Bleeding time tests platelets, and since this is normal there is no problem with the platelets.

TMP12 460–461