Section 1

Non-Neoplastic Hematology

Chapter 1

RBC Disorders

Hematopoiesis: Questions 1–14

1. The following are features of normal erythropoiesis except:
   A. Immature erythropoietic cells tend to form clusters which surround macrophages
   B. Proerythroblasts are large cells with deep blue cytoplasm with large nuclei and nucleoli
   C. Erythropoiesis occurs predominantly in the paratrabecular areas
   D. Reticulocytes typically have a three-day life span, of which two days are spent in the bone marrow

2. Which of the following is an effective marker for erythroid precursors?
   A. CD34
   B. CD71
   C. CD41
   D. CD61

3. Which of the following step is the rate-limiting step for heme biosynthesis?
   A. Formation of δ aminolevulinic acid from glycine and succinyl CoA
   B. Formation of prophobilinogen from δ aminolevulinic acid
   C. Formation of heme from protoporphyrin IX
   D. None of the above

4. Regarding granulopoiesis, which is true:
   A. Secondary granules are seen only at the band and mature granulocyte stage
   B. Blasts, promyelocytes and myelocytes all have nucleoli
   C. Granulopoiesis in a normal marrow is seen adjacent to bone
   D. Metamyelocytes are capable of cell division

5. Regarding erythropoiesis, which is true:
   A. All normoblasts have nucleoli
   B. The basophilic normoblast is the largest cell
   C. Erythropoiesis occurs in islands close to the bony trabecula
   D. The normal sequence of maturation is proerythroblast to basophilic normoblast to polychromatic normoblast to orthochromatic normoblast to reticulocyte to a mature red cell

6. Regarding megakaryopoiesis and megakaryocytes, which is true:
   A. Normal development of megakaryocytes is regulated by multiple cytokines and one principal one is thrombopoietin
   B. Clustering of megakaryocytes is a normal phenomenon
   C. Megakaryocytes mature through endomitosis where cell division with nuclear division occurs
   D. Megakaryocytes may cause destruction of hematopoietic cells by emperipolesis

7. Which of the following cell is derived from a hematopoietic stem cell?
   A. Osteoblasts
   B. Osteocytes
   C. Chondrocytes
   D. Osteoclasts

8. Features characteristic of erythroid precursors include all of the following except:
   A. In a normal marrow they are found as distinctive islands
   B. They adhere tightly to one another
   C. Cytoplasm is deep blue in the erythroblasts
   D. Shrinkage artifact of cytoplasm is seen in plastic-embedded sections

9. Regarding granulopoiesis:
   A. Both myelocytes and metamyelocytes are capable of cell division
   B. By light microscopy, promyelocytes of the three granulocytic lineages can easily be distinguished
   C. Myeloblasts are typically found in the paratrabecular areas and close to arterioles
   D. Indented myeloid cells are known as bands
10. Regarding megakaryopoiesis, which is true:
   A. Megakaryocytes are normally found close to bony trabeculae
   B. Normal megakaryocytes engulf and destroy hematopoietic cells
   C. Megakaryocytes undergo endomitosis (aka endoreduplication)
   D. Normal megakaryocyte nuclei have multiple distinct lobes
11. Which agents are responsible for the stimulation of eosinophils?
   A. IL-3
   B. IL-5
   C. GM-CSF
   D. All of the above
12. Secondary granules of neutrophils:
   A. Contain lactoferrin
   B. Are also known as azurophilic granules
   C. Contain peroxidase
   D. Are found in immature granulocytic cells
13. All of the following regarding erythropoiesis are true except:
   A. The life span of a mature erythrocyte is about four months
   B. On average each erythroblast forms eight reticulocytes
   C. In acute anemia, when accelerated erythropoiesis occurs, the red cells that are released into the circulation are normocytic and all bear the i antigen
   D. The mean time from the proerythroblast stage to reticulocyte is approximately five days
14. Regarding megakaryopoiesis and megakaryocytes:
   A. Megakaryocytes are approximately 10% of hematopoietic cells in a normal bone marrow
   B. Each megakaryocyte gives rise to 1,000–3,000 platelets
   C. Mature megakaryocytes contain 2N–128 N of DNA
   D. Mature megakaryocytes have little basophilic cytoplasm

CBC, Peripheral Smear and Bone Marrow Examination: Questions 15–40

15. When compared to normal adult CBC values, normal values for neonates and children differ considerably with the exception of:
   A. RBC count
   B. WBC count
   C. Platelet count
   D. Hemoglobin level
16. The following are true for hemoglobin measurement by automated analyzers:
   A. The red cells are required to be lysed
   B. The spectrophotometric method is typically used
   C. Absorbance of light at 540 nm is measured
   D. All of the above
17. Which of the following is a true statement?
   A. In oxyhemoglobin, iron is in the ferrous state
   B. In methemoglobin, iron is in the ferrous state
   C. In both oxyhemoglobin and methemoglobin, iron is in the ferrous state
   D. None of the above
18. Causes of falsely elevated hemoglobin levels by the spectrophotometric method include all of the following except:
   A. Leukocytosis
   B. Paraproteinemia
   C. Hyperlipidemia
   D. Thrombocytosis
19. Which of the following equations is correct to calculate MCH values?
   A. MCH= Hb/Hct
   B. MCH=Hb/RBC count
   C. MCH=Hb/MCV
   D. None of the above

20. One indication for warming the blood and repeating the CBC test is elevated:
    A. Hemoglobin
    B. Hct
    C. MCH
    D. MCHC

21. When the uncorrected WBC count is higher than the corrected WBC count, the most likely cause is:
    A. Presence of nucleated RBCs
    B. Presence of large platelets
    C. High lymphocyte count
    D. Presence of paraproteinemia

22. Causes of false low platelet count (pseudothrombocytopenia) include all of the following except:
    A. EDTA-induced platelet clumps
    B. EDTA-induced platelet satellitism
    C. Fragmented red cells
    D. Traumatic venepuncture

23. When a peripheral smear slide appears blue to the naked eye, a likely possibility is:
    A. Underlying chronic myeloproliferative disorder
    B. Underlying acute leukemia
    C. Underlying hemolytic anemia
    D. Underlying monoclonal gammopathy

24. A bone marrow exam reveals increased promyelocytes with paucity of more mature cells. Differential diagnosis includes:
    A. Acute promyelocytic leukemia
    B. Kostmann's syndrome
    C. Sepsis in a patient with agranulocytosis
    D. All of the above

25. The following are established causes of bone marrow granulomas:
    A. Hodgkin lymphoma
    B. Metastatic disease
    C. Histoplasmosis
    D. All of the above

26. Macrophages with "wrinkled tissue paper" appearance of the cytoplasm may be seen in all of the following conditions except:
    A. Gaucher's disease
    B. Niemann-Pick disease
    C. Chronic myelogenous leukemia
    D. Sickle cell disease

27. Characteristic features of sea blue histicoytes that may be seen in bone marrow include:
    A. Yellow-brown macrophages with Giemsa stain
    B. Blue-green appearance with H&E stain
    C. They are macrophages containing ceroid
    D. They are PAS negative

28. Causes of a dry tap when performing a bone marrow aspiration may be expected in:
    A. Iron deficiency anemia
    B. Refractory anemia with ringed sideroblasts
    C. Hairy cell leukemia
    D. Hereditary spherocytosis

29. Regarding lymphoid infiltrates in the bone marrow:
    A. Bone marrow infiltration is seen more often in B-cell lymphomas than T-cell lymphomas
    B. Bone marrow infiltration is seen more often in high-grade B-cell lymphomas than low-grade B-cell lymphomas
    C. Paratrabecular lymphoid aggregates are almost always reactive
    D. Diffuse involvement of the bone marrow in a case of CLL imparts a favorable prognosis

30. Regarding iron stain on bone marrow aspirate slides, all of the following are true except:
    A. Normal erythroblasts have one to five iron-containing granules, distributed randomly within the cytoplasm of erythroblasts
    B. Both intracellular and extracellular iron should be assessed
    C. In healthy individuals, 20–50% of erythroblasts are sideroblasts
    D. In individuals with hemochromatosis, plasma cells in bone marrow may demonstrate hemosiderin granules

31. Lipid granulomas of the bone marrow:
    A. Are clinically significant
    B. Are typically located in paratrabecular areas
    C. Consist of fat vacuoles which are larger than marrow fat cells
    D. May have giant cells

32. Reactive or benign lymphoid aggregates may be seen in bone marrows:
    A. In states of infection
    B. In senior citizens
    C. In rheumatoid arthritis
    D. All of the above

33. Regarding reactive lymphoid aggregates in bone marrows, all are true except:
    A. They are usually few in number
    B. They are typically located in the paratrabecular areas
    C. They consist predominantly of small mature lymphocytes
    D. The lymphocytes exhibit pleomorphism

34. Bone marrow necrosis may be seen in:
    A. Sickle cell disease
    B. Acute leukemias
    C. Chronic leukemias
    D. All of the above

35. Regarding gelatinous transformation of the bone marrow:
    A. There is replacement of hematopoietic elements by fat spaces
    B. May be highlighted by Perl's stain
    C. May be seen in individuals with anorexia nervosa
    D. The peripheral blood will demonstrate leukocytosis

36. In adults, bone marrow metastasis from the following primary tumors are common except:
    A. Prostatic carcinoma
    B. Meningioma
    C. Bronchogenic carcinoma
    D. Breast cancer

37. Peripheral blood findings most characteristic of metastatic tumor to the bone marrow is:
    A. Leukoerythroblastic blood picture and presence of tear drop cells
    B. Microcytic hypochromic red cells
    C. Macrocytic anemia
    D. Leukocytosis

38. Effect of EDTA on platelets include:
    A. Decrease in MPV
    B. Increase in MPV
    C. Loss of alpha granules
    D. Loss of δ granules

39. Regarding reticulocytes:
    A. Normal levels in newborns are 1%
    B. Are raised in aplastic anemia
    C. Contain a network of DNA in their cytoplasm
    D. Contain ribonucleoprotein in their cytoplasm

40. Regarding the zeta potential of red cells:
    A. The zeta potential of red cells is the negative charge around red cells that prevent them from aggregating
    B. The zeta potential of red cells is the positive charge around red cells that prevent them from aggregating
    C. Agents that increase the zeta potential will result in increased ESR
    D. EDTA increases the zeta potential of red cells

Anemias: Questions 41–64

41. The following are true about reticulocytes except:
    A. They are young red cells and contain ribosomal RNA
    B. Reticulocyte count is traditionally expressed as a percentage
    C. Reticulocyte count is low in bone marrow failure patients
    D. Reticulocyte count is low in hemolytic anemia patients

42. The following are all included in the differential diagnosis of microcytic hypochromic anemia except:
    A. HbE disease
    B. β thalassemia trait
    C. Iron deficiency
    D. HbS disease

43. In a patient with β thalassemia trait, all of the following features are typically observed except:
    A. Significantly high RDW
    B. Mild microcytic hypochromic anemia
    C. Target cells on the peripheral smear
    D. Disproportionately elevated RBC count

44. In a patient with iron deficiency, which of the following features are an expected finding:
    A. Minimal anisocytosis
    B. Abundant target cells
    C. Reduced transferrin iron binding capacity
    D. Elevated levels of free erythrocyte protoporphyrin (FEP)

45. Peripheral smear and bone marrow findings in iron deficiency anemia include:
    A. Abundant target cells
    B. Thrombocytopenia
    C. Hypocellular marrow
    D. Presence of scanty, ragged vacuolated cytoplasm in the developing erythroblasts

46. Which of the following is a true statement regarding sideroblastic anemia?
    A. Sideroblastic anemia may be inherited or acquired, with the inherited form being more common
    B. In sideroblastic anemia there occurs impaired iron utilization, and excess iron is found in the Golgi apparatus
    C. Siderocytes and sideroblasts are abnormal and seen in sideroblastic anemia
    D. Acquired sideroblastic anemia may be idiopathic (primary) which is part of myelodysplastic syndrome

47. In congenital sideroblastic anemia:
    A. The red cells are most often macrocytic
    B. Is a common inherited condition
    C. In most families is transmitted as X-linked inheritance
    D. Hemoglobin electrophoresis usually demonstrates an abnormal hemoglobin

48. In lead poisoning, coarse basophilic stippling is seen and this is due to:
    A. Inhibition of the enzyme 5' pyrimidine nucleotidase
    B. Inhibition of the enzyme ferrochelatase
    C. Inhibition of the enzyme δ aminolevulinic acid dehydratase
    D. All of the above

49. Anemia of chronic disease is characterized by all of these except:
    A. Low levels of serum iron
    B. Reduced transferrin saturation
    C. Reduced iron binding capacity
    D. Reduced serum ferritin

50. Causes of macrocytic anemia include all of the following except:
    A. Acute blood loss
    B. Folate deficiency
    C. B12 deficiency
    D. Excess alcohol consumption

51. All of the following are established causes of B12 deficiency except:
    A. Diet consisting of goat milk
    B. Crohn's disease
    C. Pernicious anemia
    D. Fish tapeworm infestation

52. A 30-year-old male with long-standing history of diarrhea, has macrocytosis, Howell-Jolly bodies in RBC, target cells and small shrunken spleen. The most likely diagnosis is:
    A. Sickle cell disease
    B. Celiac disease
    C. Crohn's disease
    D. Liver disease

53. Bone marrow findings in megaloblastic anemia include all of the following except:
    A. Nuclear cytoplasmic asynchrony of developing erythroid cells
    B. Giant metamyelocytes
    C. Hypersegmented megakaryocytes
    D. Absent stainable iron in the bone marrow

54. A patient with known sickle cell disease registers with a new physician. CBC ordered by the patient's new physician demonstrates macrocytosis of the red blood cells. The most likely explanation is:
    A. Iron deficiency
    B. B12 deficiency
    C. Folate deficiency
    D. Patient is on hydroxyurea

55. In pernicious anemia, all of the following are true except:
    A. Patients may develop antiparietal cell and anti-intrinsic factor antibodies
    B. Patients are at risk of developing gastric lymphoma
    C. B12 levels are low
    D. Patients may develop neurological symptoms

56. Iron deficiency may result in the misdiagnosis of:
    A. Sickle cell trait
    B. Sickle cell disease
    C. β thalassemia trait
    D. β thalassemia disease

57. In the human body, iron is found in the largest amount in:
    A. Macrophages of the reticuloendothelial system
    B. Hemoglobin
    C. Myoglobin
    D. Enzymes

58. The total daily loss of iron in an adult male is approximately:
    A. 1 mg
    B. 2 mg
    C. 3 mg
    D. 4 mg

59. Vitamin B12
    A. Is directly required for DNA synthesis
    B. If bound to transcobalamin I is delivered to the tissues
    C. Is needed to convert methyl tetrahydrofolate (THF) to THF
    D. Is absorbed in the duodenum

60. All of the following are causes of megaloblastoid changes in the bone marrow except:
    A. B12 deficiency
    B. Hydroxyurea treatment
    C. Orotic aciduria
    D. Gout

61. In a child with anemia, bone marrow examination demonstrates erythroid hyperplasia, binuclearity and multinuclearity of the erythroid precursors. Ham's acidified serum test is positive in this patient. The most likely diagnosis is:
    A. Iron deficiency
    B. Folate deficiency
    C. Congenital dyserythropoietic anemia, type I
    D. Congenital dyserythropoietic anemia, type II

62. A 50-year-old male with developed macrocytic anemia (MCV is 105 fl; red cells are round and not oval). Liver function test demonstrates elevated γ glutamyl transpeptidase (GGT) as the only abnormality. Bone marrow examination shows ring sideroblasts and erythroid multinuclearity. There is vacuolation of erythroid precursors. Cytogenetics and myelodysplastic-flourescent in situ hybridization (MDS-FISH) profile are negative. The most likely diagnosis is:
    A. Myelodysplastic syndrome (MDS)
    B. Megaloblastic anemia
    C. Excess alcohol intake
    D. Hemochromatosis

63. A child with a known diagnosis of hereditary spherocytosis develops "slapped cheek" appearance as well as profound anemia. Reticulocyte response to the anemia is inadequate. A bone marrow examination is most likely to demonstrate:
    A. Hypocellular marrow with reduction of all cell lines
    B. Erythroid hyperplasia as a response to acute hemolysis
    C. Reduced erythropoiesis with giant erythroblasts and intranuclear inclusions
    D. "Owl eye " appearance, due to CMV infection in erythroid precursors

64. Characteristic feature of Fanconi's anemia include:
    A. Autosomal dominant mode of inheritance
    B. Increased risk of transformation to acute myeloid leukemia
    C. Pure red cell aplasia
    D. Skin hyperpigmentation and nail dystrophy

Hemolytic Anemias: Questions 65–84

65. All statements regarding hereditary spherocytosis is true except:
    A. May be diagnosed by flow cytometry
    B. May be diagnosed by incubated osmotic fragility test

C. When inherited, most cases are homozygous
D. The direct antiglobulin test (DAT) is typically negative

66. Regarding membrane defects of red cells, all are true except:
A. In hereditary elliptocytosis there is often defective spectrin dimer–dimer interaction.
B. In hereditary pyropoikilocytosis there is often defective spectrin dimer–dimer interaction
C. In making a diagnosis of hereditary stomatocytosis, >90% of red cells need to be stomatocytes
D. In Rh null disease, stomatocytes may be seen in the peripheral blood

67. Pyruvate kinase deficiency:
A. Is transmitted as autosomal dominant
B. Is the commonest enzyme deficiency in the TCA cycle
C. Is the commonest enzyme deficiency in the hexose monophosphate shunt
D. Can present as jaundice

68. Regarding glucose 6 phosphate dehydrogenase (G6PD) enzyme:
A. Normally two isotypes – G6PD-A and G6PD-B – can be differentiated based on electrophoretic mobility
B. The A isoform is the most common type found in all populations
C. 90% of US black men have the G6PD-A minus isoform
D. The A minus isoform has the same electrophoretic mobility as the B isoform

69. All of the following statements regarding paroxysmal nocturnal hemoglobinuria (PNH) are true except
A. PNH is transmitted as X-linked recessive
B. PNH may be diagnosed by flow cytometry
C. PNH may be diagnosed by Ham's acidified serum test
D. Occurs due to mutation of the PIG-A gene

70. Which of the following observations may be seen in a positive Ham's acidified serum test?
A. The tube with patient's red cells and patients serum, heated to 56°C shows hemolysis
B. The tube with patient's red cells and patient's serum, without addition of acid, shows hemolysis
C. The tube with patient's red cells and patient's serum, with addition of acid, show hemolysis
D. The tube with patient's red cells and patient's serum, with addition of acid and heated to 56°C shows hemolysis.

71. Regarding autoimmune hemolytic anemias:
A. In warm autoimmune hemolytic anemias (WAHA), the antibodies are often against I antigen
B. In warm autoimmune hemolytic anemia, hemolysis is typically intravascular
C. In cold hemagglutinin (CHAD) disease, antibodies are often directed against P antigen
D. Paroxysmal cold hemoglobinuria (PCH) is a rare condition and is sometimes seen in children following a viral infection.

72. Regarding the following poikilocytes, all are true except:
A. In individuals with HbSS disease, under low oxygen tension, tubular structures called tactoids deform the red cells and produce sickle cells
B. Target cells may be seen in individuals with lecithin cholesterol acyltransferase deficiency
C. Macro ovalocytes are commonly seen in individuals with hypothyroidism
D. Abundant target cells are more often seen in HbSC disease rather than in HbSS disease

73. Regarding the following poikilocytes all are true except:
A. Occasional elliptocytes may be seen in iron deficiency
B. Individuals with Rh null disease may exhibit stomatocytes in their peripheral blood
C. Echinocytes may be seen in patients with pyruvate kinase deficiency
D. Burr cells are also known as drepanocytes

74. Regarding acanthocytes
A. The word acanthocyte is derived from the Greek word for "urchin"
B. May be seen in individuals with McLeod phenotype

C. Is a feature of HbSS disease
D. These are cells with hundreds of thorny projections

75. Howell-Jolly bodies are:
A. DNA material
B. Consist of iron
C. RNA material
D. An in vitro phenomenon

76. Pyrimidine 5 nucleotidase:
A. Is an enzyme in the heme biosynthetic pathway
B. Is responsible for the degradation of RNA in red cells
C. Deficiency results in target cells
D. Deficiency results in bite cells

77. All of the following are features of parasitization of RBCs with Plasmodium falciparum except:
A. Plasmodium parasite with two chromatin dots
B. Presence of marginal forms
C. Banana- or crescent-shaped gametocytes
D. Enlarged red cells

78. In cold hemagglutinin disease (CHAD):
A. The antibody is typically IgG in nature
B. There is an association with pneumonia due to Staph aureus
C. Red cell agglutination occurs in vivo
D. Analysis of CBC values will yield low RBC count with normal hemoglobin levels

79. Established causes of microangiopathic hemolysis include all except
A. Thrombotic thrombocytopenic purpura (TTP)
B. Hemolytic uremic syndrome (HUS)
C. Disseminated intravascular coagulation (DIC)
D. Immune thrombocytopenic purpura (ITP)

80. Which of the following laboratory finding is expected in hereditary spherocytosis?
A. Increased MCHC
B. Low MCV and MCH
C. Low serum bilirubin
D. Low LDH

81. Regarding various hemolytic anemias, which statement is true:
A. Hereditary spherocytosis may be transmitted as autosomal recessive
B. G6PD deficiency may be seen in females with asymmetric lyonization
C. Myelodysplastic syndrome may result in acquired pyruvate kinase deficiency
D. All of the above

82. Which of the following tests for hereditary spherocytosis has the highest sensitivity and specificity?
A. Osmotic fragility test
B. Eosin-5-maleimide (EMA) binding test
C. Acidified glycerol lysis test (AGLT)
D. DAT

83. Regarding cryoglobulinemia:
A. HCV infection is the most common cause of type I cryoglobulinemia
B. In an individual with multiple myeloma, type III cryoglobulinemia may be seen
C. High levels of complement are expected
D. Vasculitic skin lesions may be seen

84. Gaisbock syndrome refers to:
A. Erythrocytosis seen in polycythemia rubra vera
B. Erythrocytosis seen in CML
C. Erythrocytosis seen due to dehydration
D. Erythrocytosis seen in patients with renal tumors

Hemoglobinopathies: Questions 85–109

85. An example of an embryonic hemoglobin is:
A. Hemoglobin F
B. Hemoglobin A
C. Hemoglobin A2
D. Hemoglobin Gower

86. The following are all hemoglobin adducts except:
A. HbAIII
B. HbA1c
C. HbA1d
D. Hemoglobin CS (Constant Spring)

87. Regarding hemoglobin biosynthesis:
A. The first step is formation of δ aminolevulinic acid from glycine and succinyl CoA, which takes place in the cytoplasm

B. Combination of heme with globin to form hemoglobin, in the cytoplasm
C. Conversion of protoporphyrin IX to heme by the removal of iron
D. Conversion of δ aminolevulinic acid to porphobilinogen in the mitochondria

88. Regarding hemoglobinopathies, which of the following is true:
A. There are about 100 hemoglobinopathies and most are asymptomatic
B. About 5% of the population in the world are carriers of hemoglobinopathies
C. If an individual has HbC, then their ancestry is most likely from the Carribean
D. Certain hemoglobinopathies are characterized by reduced amount of normal globin chain synthesis.

89. Which of the following is not a sickling disorder?
A. HbSS disease
B. HbSC disease
C. HbSD disease
D. HbSE disease

90. HbH disease is characterized by:
A. Deletion of one α gene
B. Deletion of two α genes
C. Deletion of three α genes
D. Deletion of four α genes

91. Regarding α thalassemia trait:
A. The condition may resemble iron deficiency
B. Individuals have significant microcytic hypochromic anemia
C. If due to alpha thalassemia 1 (-/-, α, α), which is due to cis deletion of both α genes on the same chromosome, is seen more often in the African American population
D. If due to α thalassemia 2 (-/ α, -/α), which is due to trans deletion of the α genes on two different chromosomes, is seen more often in Southeast Asian individuals

92. In α thalassemia disease:
A. Hb Bart's may be seen in the newborn
B. HbH will be evident when the patient is an adult
C. Patients have chronic hemolytic anemia
D. All of the above are true

93. An individual has microcytic hypochromic anemia (mild) with the presence of target cells on the peripheral smear. Hemoglobin electrophoresis demonstrates HbA2 (6%), HbF (3%) and HbA (91%). Iron studies are unremarkable. Patient has never received any blood transfusion. The most likely diagnosis is:
A. α thalassemia trait
B. β thalassemia trait
C. β thalassemia intermedia
D. β thalassemia major

94. An individual undergoes hemoglobin electrophoresis by the capillary method. HbA2 is detected at low levels,<1.5%. The following are possible causes:
A. α thalassemia trait
B. δ thalassemia
C. Iron deficiency
D. All of the above

95. A Greek individual undergoes hemoglobin electrophoresis for mild anemia. Results show normal HbA2 at 3.3%, HbF at 10% and the remaining hemoglobin is HbA. A possible diagnosis is:
A. β thalassemia trait
B. β thalassemia major
C. δ β thalassemia, heterozygous state
D. δ thalassemia

96. Hemoglobin S is due to a β chain defect. HbS is formed when:
A. Glutamic acid is replaced by lysine at the 26th position of the β chain
B. Glutamic acid is replaced by lysine at the 121st position of the β chain
C. Glutamic acid is replaced by lysine at the 6th position of the β chain
D. Glutamic acid is replaced by valine at the 6th position of the β chain

97. Increased levels of HbF can be seen in all of the following except:
A. HbSS disease
B. HbSS individuals on hydroxyurea