Biochemistry Exam Preparation – Hemoglobin & RBC Metabolism

1. What is hemoglobin?

   Answer: A protein in red blood cells responsible for oxygen transport.

2. Where is hemoglobin found?

   Answer: Inside red blood cells.

3. What are the main components of hemoglobin?

   Answer: Four polypeptide chains and four heme groups.

4. What atom is at the center of the heme group?

   Answer: Iron (Fe^{2}■).

5. How many oxygen molecules can one hemoglobin bind?

   Answer: Four oxygen molecules.

6. What is the function of heme in hemoglobin?

   Answer: To bind and carry oxygen.

7. What is the normal adult hemoglobin called?

   Answer: Hemoglobin A (α■β■).

8. What type of hemoglobin is found in fetuses?

   Answer: Hemoglobin F (α■γ■).

9. What is the difference between HbA and HbF?

   Answer: HbF has a higher affinity for oxygen.

10. What gives red blood its color?

    Answer: The iron in heme when it binds oxygen.

11. Where is hemoglobin synthesized?

    Answer: In immature red blood cells in bone marrow.

12. What is globin?

    Answer: The protein part of hemoglobin.

13. What happens to hemoglobin when oxygen binds?

    Answer: It changes shape to increase oxygen affinity.

14. What is deoxyhemoglobin?

    Answer: Hemoglobin without oxygen.

15. What is oxyhemoglobin?

    Answer: Hemoglobin bound with oxygen.

16. What is methemoglobin?

Answer: Hemoglobin with iron in the ferric (Fe^{3}■) state, unable to bind oxygen.

17. What enzyme reduces methemoglobin back to normal?

Answer: Methemoglobin reductase.

18. What is carboxyhemoglobin?

Answer: Hemoglobin bound with carbon monoxide (CO).

19. Why is CO poisoning dangerous?

Answer: Because CO binds hemoglobin more strongly than oxygen.

20. What is the lifespan of red blood cells?

Answer: About 120 days.

21. What is cooperative binding?

Answer: The phenomenon where oxygen binding increases hemoglobin's affinity for more oxygen.

22. What curve represents this?

Answer: The sigmoidal oxygen dissociation curve.

23. What does P50 mean?

Answer: The oxygen pressure at which hemoglobin is 50% saturated.

24. What does a right shift in the curve indicate?

Answer: Decreased affinity for oxygen (more release to tissues).

25. What factors cause a right shift?

Answer: Increased CO■, H■, temperature, and 2,3-BPG.

26. What is the Bohr effect?

Answer: The decrease in oxygen affinity due to low pH or high CO■.

27. What is the Haldane effect?

Answer: Oxygenation of blood displaces CO■ from hemoglobin.

28. What molecule regulates oxygen release in tissues?

Answer: 2,3-Bisphosphoglycerate (2,3-BPG).

29. Where does 2,3-BPG bind?

Answer: To the beta chains of deoxyhemoglobin.

30. What does 2,3-BPG do?

Answer: Promotes oxygen release in tissues.

31. How does temperature affect oxygen binding?

Answer: Higher temperature decreases oxygen affinity.

32. How does pH affect oxygen affinity?

Answer: Lower pH decreases affinity (Bohr effect).

33. Why is HbF less affected by 2,3-BPG?

Answer: Because it binds 2,3-BPG weakly, allowing higher O■ affinity.

34. How does altitude affect hemoglobin regulation?

Answer: Increases 2,3-BPG to enhance O■ release.

35. What happens to hemoglobin at low pH?

Answer: It releases more oxygen.

36. What happens at high pH?

Answer: It binds oxygen more tightly.

37. How does CO■ bind to hemoglobin?

Answer: Forms carbaminohemoglobin at the N-terminal.

38. What happens to the curve during exercise?

Answer: It shifts right due to increased CO■ and temperature.

39. What is allosteric regulation?

Answer: Regulation by molecules binding to sites other than the active site.

40. Is oxygen binding reversible?

Answer: Yes, it’s a reversible process.

41. What are hemoglobinopathies?

Answer: Genetic disorders affecting the structure or production of hemoglobin.

42. What causes sickle cell anemia?

Answer: A mutation in the β-globin gene (valine replaces glutamic acid).

43. What is the abnormal hemoglobin in sickle cell?

Answer: Hemoglobin S (HbS).

44. What happens to RBCs in sickle cell anemia?

Answer: They become rigid and crescent-shaped.

45. What are the complications of sickle cell disease?

Answer: Anemia, pain crises, and organ damage.

46. What is thalassemia?

Answer: A disorder causing decreased synthesis of α or β globin chains.

47. What causes β-thalassemia?

Answer: Reduced or absent β-globin production.

48. What causes α-thalassemia?

Answer: Deletion of α-globin genes.

49. What is the result of thalassemia?

Answer: Imbalanced globin chain production and anemia.

50. What is HbC disease?

Answer: A mutation causing lysine to replace glutamic acid in β-chain.

51. How is sickle cell detected?

Answer: Hemoglobin electrophoresis.

52. What is HbA■?

Answer: A minor adult hemoglobin (α■δ■).

53. What is the effect of HbS polymerization?

Answer: Causes RBC deformation and sickling.

54. What environmental condition worsens sickling?

Answer: Low oxygen tension.

55. What protects against malaria?

Answer: Sickle cell trait (heterozygous HbAS).

56. What happens in combined HbS and HbC?

Answer: Milder sickling than pure HbS.

57. What is hydroxyurea used for?

Answer: To increase fetal hemoglobin (HbF) in sickle cell patients.

58. What is anemia?

Answer: A decrease in hemoglobin concentration or RBC count.

59. What is hemolysis?

Answer: Destruction of red blood cells.

60. What is the inheritance pattern of hemoglobinopathies?

Answer: Mostly autosomal recessive.

61. Do RBCs have mitochondria?

Answer: No, they rely on glycolysis for energy.

62. What is the main energy source of RBCs?

Answer: Glucose.

63. What pathway provides ATP in RBCs?

Answer: Embden-Meyerhof (glycolytic) pathway.

64. What is the purpose of the pentose phosphate pathway in RBCs?

Answer: To produce NADPH for antioxidant defense.

65. What enzyme deficiency causes hemolysis?

Answer: G6PD deficiency.

66. What does NADPH do?

Answer: Protects RBCs from oxidative damage by regenerating glutathione.

67. What is glutathione’s function?

Answer: Neutralizes free radicals in RBCs.

68. What happens in G6PD deficiency?

Answer: Hemolysis after oxidative stress (e.g., fava beans, drugs).

69. What enzyme maintains hemoglobin iron in reduced form?

Answer: Methemoglobin reductase.

70. Why is ATP important in RBCs?

Answer: Maintains ion gradients and cell shape.

71. What is the function of Na■/K■ ATPase in RBCs?

Answer: Keeps proper ion balance and volume.

72. What causes RBC aging?

Answer: Loss of membrane flexibility and enzyme activity.

73. Where are old RBCs destroyed?

Answer: In the spleen, liver, and bone marrow.

74. What cells remove old RBCs?

Answer: Macrophages.

75. What is produced when RBCs are broken down?

Answer: Heme, globin, and bilirubin.

76. Where is bilirubin formed?

Answer: In macrophages after heme degradation.

77. How is bilirubin transported?

Answer: Bound to albumin in plasma.

78. What happens to bilirubin in the liver?

Answer: It’s conjugated and excreted in bile.

79. What is urobilinogen?

Answer: A bile pigment formed in the intestine.

80. What gives feces its color?

Answer: Stercobilin (from bilirubin breakdown).

81. Where is most iron in the body found?

Answer: In hemoglobin.

82. What is ferritin?

Answer: A protein that stores iron inside cells.

83. What is transferrin?

Answer: A plasma protein that transports iron.

84. Where does iron absorption occur?

Answer: In the duodenum.

85. What form of iron is absorbed?

Answer: Fe^{2}■ (ferrous form).

86. What enzyme converts Fe^{3}■ to Fe^{2}■?

Answer: Ferric reductase.

87. What hormone regulates iron absorption?

Answer: Hepcidin.

88. Where is hepcidin produced?

Answer: In the liver.

89. What happens when hepcidin is high?

Answer: Iron absorption decreases.

90. What happens when hepcidin is low?

Answer: Iron absorption increases.

91. What is hemosiderin?

Answer: An insoluble form of stored iron.

92. What causes iron deficiency anemia?

Answer: Low iron intake or chronic blood loss.

93. What are symptoms of iron deficiency?

Answer: Fatigue, pallor, and spoon-shaped nails.

94. What causes iron overload?

Answer: Hereditary hemochromatosis or repeated transfusions.

95. Where is excess iron deposited?

Answer: Liver, heart, and pancreas.

96. What does ferritin reflect clinically?

Answer: Body iron stores.

97. What is the daily iron requirement?

Answer: About 1–2 mg/day.

98. What vitamin enhances iron absorption?

Answer: Vitamin C (ascorbic acid).

99. What inhibits iron absorption?

Answer: Phytates, tannins, and calcium.

100. How is iron excreted?

Answer: There is no active excretion; lost through shedding cells.