CHAPTER 11

BIOENERGETICS

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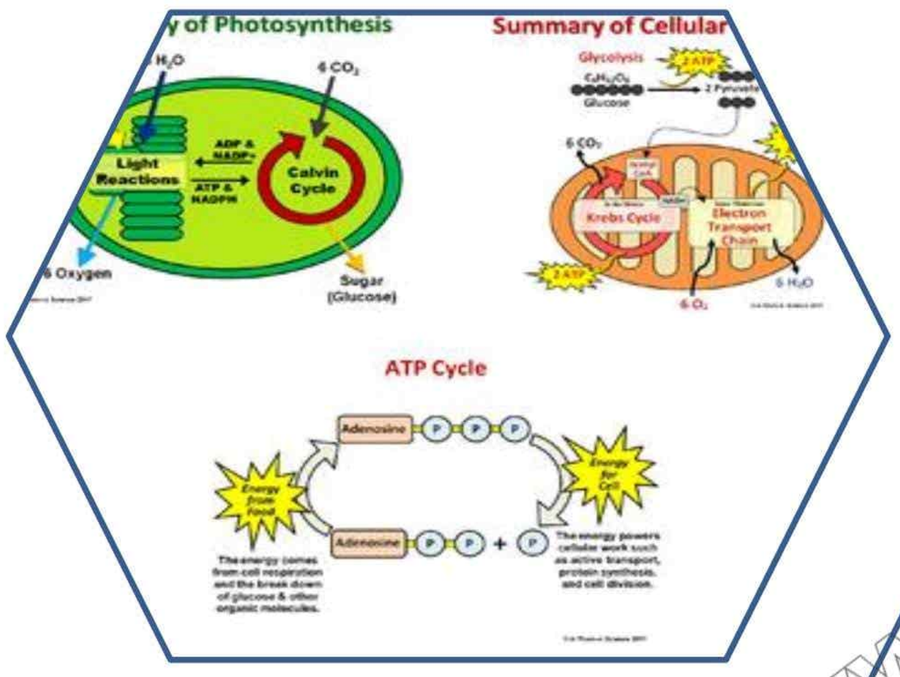
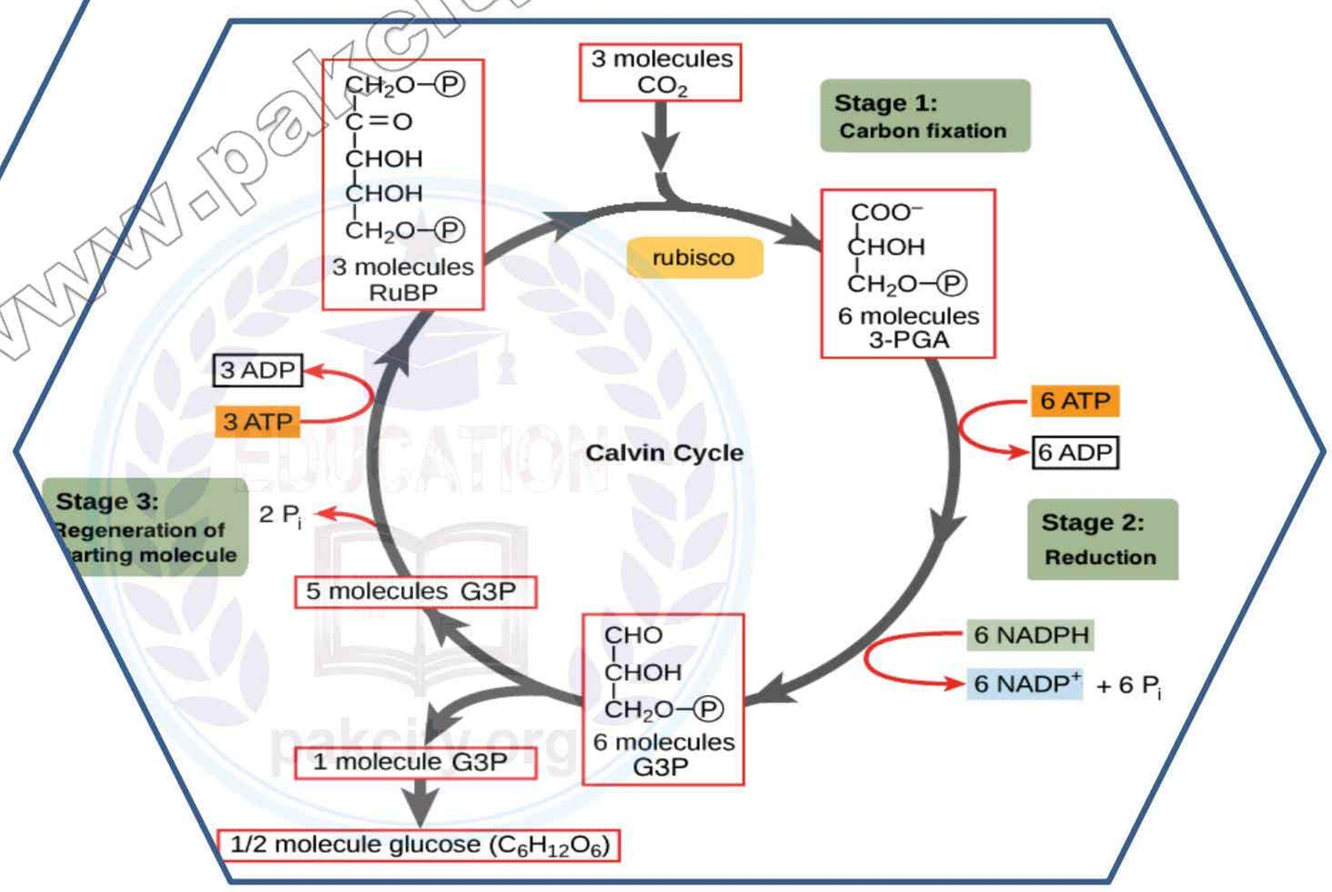
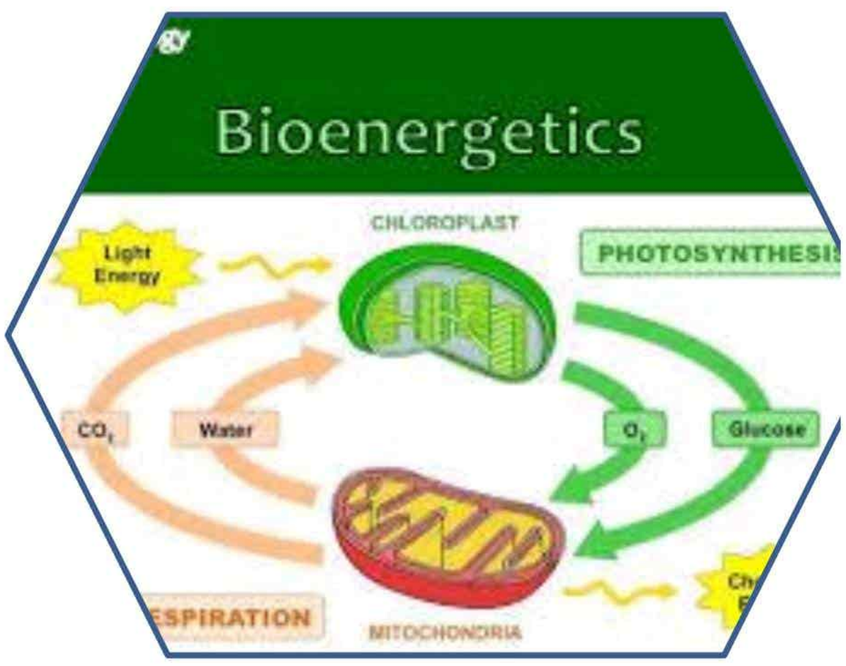


- **Exercise Short Answers**
- **Important Short Answers**





- **Exercise MCQ's**
- **Important Additional MCQ's**
- **Past MDCAT MCQ's**

Exercise MCQ's

❖ **Encircle the correct answer from the multiple choices.**

1) **Magnesium is an important nutrient ion in green plants as it is an essential component of:**
   a) Cell sap b) Protein c) Chlorophyll d) Glucose
2) **When a green plant performs photosynthesis at its maximum rate:**
   a) The rate of water loos is low
   b) The water content of the plant will be low
   c) The energy content of the plant will be low
   d) The energy content will be unaffected
3) **During the dark reactions of photosynthesis, the main process which occur is:**
   a) Release of oxygen
   b) Energy absorption by chlorophyll
   c) Adding of hydrogen to carbon dioxide
   d) Formation of ATP
4) **Which statement about ATP id not true?**
   a) It is used as an energy currency by all cells
   b) It is formed only under aerobic conditions
   c) Some ATP is used to drive the synthesis of storage compounds
   d) It provides the energy for many different biochemical reaction
5) **Glycolysis:**
   a) Produces no ATP
   b) Is the same as fermentation
   c) Takes place in the mitochondrion
   d) Reduces two molecules of NAD+ for every glucose molecules produced
6) **The citric acid cycle:**
   a) Takes place in mitochondrion
   b) Reduces two molecules of NAD+ for every glucose molecules produced
   c) Is the same as fermentation
   d) Has no connection with respiratory chain
7) **Which statement about the chemiosmotic mechanism is not true?**
   a) Protons returns through the membrane by way of a channel protein
   b) Protons are pumped across a membrane
   c) Proton pumping is associated with the respiratory chain
   d) The membrane in question is the inner mitochondrial membrane
8) **Which statement about oxidative phosphorylation is not true?**
   a) Its function can be served equally well by fermentation
   b) In eukaryotes, it takes place in mitochondria
   c) It is brought about by the chemiosmotic mechanism
   d) It is the formation of ATP during operation of respiratory chain
9) **Before pyruvate enters the citric acid cycle, it is decarboxylated, oxidized and combined with coenzyme A, forming acetyl CoA, carbon dioxide and one molecule of:**
   a) NADH b) FADH2 c) ATP d) ADP
10) **In the first step of citric acid cycle, acetyl CoA reacts with oxaloacetate to form:**
   a) Pyruvate b) Citrate c) NADH d) ATP
11) **When deprived of oxygen, yeast cells obtain energy by fermentation, producing carbon dioxide, ATP and:**
   a) Acetyl CoA b) Ethyl alcohol c) Lactose d) Pyruvate

Answer key:

1	c	**2**	a	**3**	c	**4**	b	**5**	d
6	a	**7**	a	**8**	a	**9**	a	**10**	b
11	b								

Most important MCQ's

❖ **Encircle the correct answer from the multiple choices.**

Bioenergetics

1. **The quantitative study of energy relationship in the biological system is:**
   a) Biochemistry b) biotechnology c) Bioenergetics d) Biophysics
2. **A kind of chemical link between anabolism and catabolism:**
   a) Protein b) Glucose c) ATP d) None of these
3. **Energy poor inorganic oxidized compounds are reduced to energy rich carbohydrates during:**
   a) Respiration b) Photosynthesis c) Growth d) Development
4. **The hypothesis that plants split water as source of hydrogen was given by:**
   a) Neil b) Krebs' c) Calvin d) Pasteur
5. **Moment in plants when CO_2 released during respiration equals the quantity required for photosynthesis is termed as:**
   a) Chemiosmosis b) Homeostasis c) Action spectrum d) Compensation point
6. **Oxygen released during photosynthesis comes from according to Neil's hypothesis:**
   a) Water b) CO_2 c) Glucose d) Chlorophyll
7. **Photosynthesis is process in which _____ compounds of carbon (CO2) and hydrogen (H2O) are reduced to carbohydrate like (glucose) using light energy:**
   a) Organic b) Energy rich c) Energy poor d) Reduced
8. **$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_20$ + ENERGY represents:**
   a) Photosynthesis b) Aerobic respiration c) Anaerobic respiration d) Respiration
9. **At which times there is no net gaseous exchange between leaves and the atmosphere:**
   a) Day time b) Night time c) Dawn & Dusk d) Mid night
10. **Which of the following is a compensation point:**
    a) Leaves respire and utilize O_2 and release CO_2
    b) Photosynthesis and respiration occur at same rate. So there is not net exchange of gases between atmosphere and plants
    c) Rate of photosynthesis increases, so do the O_2 production, with a net release of oxygen coupled with the uptake of CO_2
    d) Rate of respiration becomes more than rate of photosynthesis
11. **Quantitative study of energy relationships in biological systems obeys:**
    a) Bioenergetics b) Laws of thermodynamics c) Laws of thermo chemistry d) Laws of chemical energetic
12. **The organisms able to use sunlight directly as a source of energy are:**
    a) Plants b) Animals c) Omnivores d) Fungi
13. **Of the following which one is not an energy releasing process?**
    a) Glycolysis b) Respiration c) Photosynthesis d) Krebs' cycle
14. **Net yield of H_2O in Photosynthesis is:**
    a) 1 molecule b) 6 molecules c) 3 molecules d) 0 molecule
15. **Van Neil hypothesis about the production of oxygen during photosynthesis was based on the study and investigations on:**
    a) Bacteria b) Algae c) Protenema d) Cyanobacteria

Chloroplast

16. **The number of chloroplast in each mesophyll cell is about:**
    a) 10-100 b) 10-200 c) 20-100 d) 20-200
17. **The fluid filled region of chloroplast is:**
    a) Matrix b) Cisternae c) Stroma d) Cytoplasm
18. **Red corpuscles to hemoglobin as chloroplasts are to:**
    a) Guard cells b) Palisade cells c) Chlorophyll d) Photosynthesis
19. **Light reaction takes place on/in:**
    a) Thylakoid b) Stroma c) Chloroplast d) Grana
20. **Thylakoids in chloroplasts are stacked into:**
    a) Grana b) Stroma c) Nucleus d) None of these
21. **In all plants the major sites of photosynthesis are:**
    a) Leaves respire and utilize O_2 and release CO_2
    b) Stems
    c) Roots
    d) Branches
22. **Chlorophylls are found embedded in the _____ membranes:**
    a) Stroma b) Grana c) Thylakoid d) Intergrana
23. **Chlorophyll is insoluble in:**
    a) Carbon tetrachloride b) Alcohol c) Organic solvents d) Water

Light and Photosynthetic pigments

24. The instrument used to measure relative abilities of different pigments to absorb different wave lengths of light is:
a) Thermometer b) Spectrophotometer c) Photometer d) Sphygmomanometer

25. The photosynthetic pigments are the substances that absorb visible light having wavelength:
a) 150 to 340nm b) 230 to 450nm c) 380 to 750nm d) 350 to 780nm

26. Which of the following is not accessory pigment:
a) Chlorophyll a b) Chlorophyll b c) Xanthophyll d) Carotenoids

27. Light wavelength least absorbed by chlorophyll is:
a) Violet b) Blue c) Yellow d) Orange

28. The carotene are mostly red to:
a) Blue b) Yellow c) Orange d) Green

29. One of the accessory photosynthetic pigments carotenes are mostly:
a) Red to orange b) Yellow to orange c) Green to yellow d) Orange to red

30. Accessory photosynthetic pigments Xanthophyll are:
a) Green in color b) Red in color c) Yellow in color d) Orange in color

31. The accessory photosynthetic pigments found in chloroplast are:
a) Chlorophyll a b) Chlorophyll c c) Bacteriochlorophyll a d) Chlorophyll b & carotenoids

32. The head of the chlorophyll molecule is a complex of:
a) Benzene ring b) Porphyrin ring c) Pyrrole ring d) Mg ring

33. Porphyrin ring of chlorophyll is made up of few joined smaller:
a) Pyranose ring b) Pyrrole ring c) Furanose rings d) Phytol rings

34. Long hydrocarbon ring tail of chlorophyll attached to pyrrole ring is called:
a) Phytol b) Electron acceptor c) Haem d) Antenna complex

35. Haem portion of hemoglobin contains:
a) Mg^{++} b) Fe^{++} c) Fe^{+++} d) Ca^{++}

36. Magnesium of chlorophyll is replaced in hemoglobin by:
a) Calcium b) Potassium c) Iron d) Phosphorus

37. Haem portion of hemoglobin is same to porphyrin ring with a difference of:
a) Carbon atom b) Hydrogen atom c) Iron atom d) Oxygen atom

38. Chlorophyll molecules contains all except:
a) Porphyrin ring b) Phytol ring c) Magnesium d) Iron

39. Which metal atom is present in chlorophyll?
a) Cu b) Fe c) Mg d) K

40. The molecular formula for chlorophyll 'a' is:
a) $C_{55}H_{70}O_6N_4Mg$ b) $C_{55}H_{74}O_5N_4Mg$ c) $C_{55}H_{72}O_5N_4Mg$ d) $C_{55}H_{72}O_4N_5Mg$

41. The molecular formula for chlorophyll 'b' is:
a) $C_{55}H_{72}O_5N_4Mg$ b) $C_{55}H_{70}O_6N_4Mg$ c) $C_{50}H_{70}O_5N_3Mg$ d) $C_{56}H_{70}O_5N_3Mg$

42. Chlorophyll 'a' is:
a) Yellow green b) Orange green c) Blue green d) Green black

43. Chlorophyll absorb mainly wavelength:
a) Yellow b) Violet blue c) Green d) Indigo

44. A graph plotting absorption of light of different wavelength by a pigment is called:
a) Action spectrum b) Absorption spectrum c) Visible spectrum d) Frequency spectrum

45. The maximum absorption peaks of light are:
a) 450,640 b) 440,490 c) 430,670 d) 550,650

46. The absorption of blue light is maximum at ……..nm:
a) 430 b) 380 c) 750 d) 670

47. The first action spectrum was obtained by:
a) T.W. Engelmann b) Van Neil c) Melvin Calvin d) Ernst Haeckel

48. Engelmann used in his experiments in 1883:
a) Spirogyra b) Aerobic bacteria c) Anaerobic bacteria d) Both a & b

49. First action spectrum was obtained by German Biologist Engelmann in:
a) 1883 b) 1938 c) 1898 d) 1876

50. Which of the following statement about the head of a chlorophyll molecule is incorrect:
a) It is a porphyrin ring or tetrapyrrole ring structure
b) It is flat, square and light absorbing
c) Composed of carbon and nitrogen atoms with Magnesium as central metal ion, which is coordinated with nitrogen
d) It is hydrophobic

51. Which is the correct order of energy transfer from accessory pigments to main photosynthetic pigment?
a) Carotenoids → Chlorophyll a → Chlorophyll b
b) Chlorophyll b → Carotenoids → Chlorophyll a
c) Carotenoids → Chlorophyll b → Chlorophyll a
d) Chlorophyll a → Chlorophyll b → Carotenoids

52. Bacteriochlorophylls does not include:
a) Chlorophyll e b) Chlorophyll d c) Chlorophyll a d) Chlorophyll c

53. Carotenoids perform protective function in:
a) Animals b) Plants c) Both of these d) None of these

Role of CO_2

54. About _____ % of photosynthesis is carried by terrestrial plants, while rest occurs in ocean, lakes, and ponds:
a) 10% b) 20% c) 30% d) 40%

55. Air contains _____ % of CO_2:
a) 0.02-0.03 b) 0.03-0.04 c) 0.04-0.05 d) 0.05-0.06

56. Carbon dioxide enters the leaves through:
a) Epidermis b) Cuticle c) Air spaces d) Stomata

57. The area of leaf surface covered by stomata is only:
a) 2-4 % b) 2-3% c) 1-2% d) 1-3%

58. Reduction in photosynthesis is of:
a) O_2 b) CO_2 c) H_2O d) light energy

59. Daily rhythmic opening and closing of stomata is:
a) Internal clock b) External clock c) Both a & b d) None of them

Photosystem

60. Photosynthetic pigments are organized into clusters, called:
a) Phytochromes b) Photosystems c) Chromatophores d) Cytochromes

61. Photosystem II has the form of chlorophyll a which absorb best the light of:
a) 670nm b) 680nm c) 690nm d) 700nm

62. Of the following, which one light – gathering:
a) Antenna complex b) Reaction centre c) Photosystem d) None of these

63. ATP synthesis in presence of light is called:
a) Oxidative phosphorylation b) Reductive phosphorylation c) Chemiosmosis d) Hydro phosphorylation

64. PS I has chlorophyll a molecule which absorbs maximum light of _____ nm:
a) 600 b) 650 c) 680 d) 700

Light Reaction

65. Plastocyanin protein contains:
a) Iron b) Copper c) Magnesium d) Potassium

66. **Which one is Copper containing protein is:**
a) Cytochrome b) Ferredoxin c) Plastocyanin d) Plastoquinone

67. Iron containing protein is:
a) Cytochrome b) Ferredoxin c) Plastocyanin d) Plastoquinone

68. The NADPH molecule will provide reducing power for sugar in the:
a) Calvin cycle b) Cyclic phosphorylation c) Chemiosmosis d) Electron transport chain

69. Which one of the following is not concerned with non-cyclic phosphorylation?
a) Plastoquinone b) Plastocyanin c) Ferredoxin d) Isocitrate

70. Which of the following is not the end product of non-cyclic photophosphorylation:
a) Reduced ATP b) Oxygen c) ATP d) CO_2

71. NADPH2 provides:
a) Assimilatory power b) Chemical energy c) Energized electrons d) All of these

72. The product(s) of cyclic phosphorylation is/are:
a) ATP b) NADP and ATP c) NADP d) NADP, ATP and Oxygen

73. Mechanism of photophosphorylation takes place in conjunction with the respiratory chain in inner membrane of:
a) Mitochondria b) Chloroplast c) Golgi bodies d) Lysosomes

Chemiosmosis

74. Process by which pH gradient across membrane drives formation of ATP is:
a) Photosynthesis b) Chemiosmosis c) Photorespiration d) Calvin cycle

75. Thylakoid membranes are involved are involved in ATP synthesis by:
a) Chemosynthesis b) Chemiosmosis c) Chemotherapy d) Chemotactic

76. The mechanism of ATP synthesis during photophosphorylation is:
a) Active transport b) Chemiosmosis c) Diffusion d) Osmosis

Dark Reaction

77. The Calvin cycle is also known as:
a) C3 pathway b) C4 pathway c) C5 pathway d) C6 pathway

78. The dark reaction in photosynthesis occurs in:
a) Cytoplasm b) Chloroplast c) Stroma d) Grana

79. What is not correct about RuBP?
a) 5-C compound
b) CO_2 acceptor
c) Most abundant protein in nature
d) A metabolite of Calvin cycle

80. Which one is not the phase of Calvin cycle?

a) Carbon fixation
b) Reduction
c) Regeneration of CO_2 acceptor
d) Phosphorylation

81. Which of the following are the end products of light dependent stage, used in the Calvin cycle to change glycerate 3-phosphate into triose phosphates:

a) NADP + ATP b) RuBP + ATP c) ATP d) O_2 + NADPH

82. The most abundant protein in chloroplast is:

a) Chlorophyll b) Ribulose bisphosphate c) Histone d) Rubisco

83. Most abundant protein on earth is:

a) Rubisco b) Hemoglobin c) Albumin d) Fibrinogen

Respiration and Fermentation

84. The cellular respiration is directly involved in the production of:

a) Glucose b) Proteins c) Energy d) Amino acid

85. Respiration is the universal process by which organism break down complex compounds containing……..:

a) Calcium b) Copper c) Carbon d) Cobalt

86. In which process/processes stored energy in carbohydrate is released?

a) Photosynthesis b) Glycolysis c) Respiration d) Glycolysis and respiration

87. The exchange of gases (CO_2 and O_2) between organism and its environment is called:

a) Respiration b) External respiration c) Cellular respiration d) Anaerobic respiration

88. End products of anaerobic respiration in yeast:

a) Lactic acid b) Methyl alcohol c) Ethyl alcohol d) Ethyl alcohol and CO_2

89. Formula of lactic acid is:

a) $C_3H_4O_3$ b) $C_3H_5O_3$ c) $C_3H_6O_3$ d) C_2H_5OH

90. The compound formed during muscle fatigue is:

a) Alcohol b) Lactic acid c) Hydrochloric acid d) Carbon

91. Which form of anaerobic respiration occurs in muscle cells of humans and other animals during extreme physiological activities?

a) Pyruvic oxidation b) Lactic acid fermentation c) Glycolysis d) Alcoholic fermentation

92. The amount of glucose into ATP during anaerobic respiration:

a) 4% b) 3% c) 2% d) 1%

93. The breaking of the terminal phosphate of ATP release energy of about:

a) 9.3 Kcal b) 3.7 Kcal c) 7.3 Kcal d) 5. Kcal

94. The breaking of terminal phosphate of ATP releases about 7. Kcals of:

a) O_2 b) NO_2 c) Heat d) Energy

Glycolysis and Krebs' cycle and Electron Transport Chain

95. Glycolysis is breakdown of glucose up to the formation of (final/end product of glycolysis):

a) Acetic acid b) Pyruvic acid c) Citric acid d) Lactic acid

96. In which stage of cellular respiration does glucose break down into two molecules of pyruvic acid?

a) Krebs cycle b) Electron transport chain c) Calvin cycle d) Glycolysis

97. Cellular respiration is divided into four stages. Which one of these does not take place in mitochondria?

a) Respiratory chain b) Krebs cycle c) Glycolysis d) Pyruvic acid oxidation

98. Glycolysis occurs in (pyruvic acid is produced from glucose in):

a) Nucleus b) Mitochondria c) Cytosol d) Ribosome

99. Glycolysis:

a) Produce no ATP
b) Is same as fermentation
c) Take place in mitochondria
d) Produce two of NAD for every glucose molecules processed

100. Pyruvic acid is produced as a result of (Pyruvic acid is he end product of):

a) Krebs' cycle b) Glycolysis c) Phosphorylation d) Respiratory chain

101. Which of the following is not the end product of Glycolysis:

a) Pyruvate b) Oxaloacetate c) ATP d) Reduced NAD

102. Glycolysis is first phase of cellular respiration. Its products are:

a	2NADH	2ATP	2 Pyruvates
b	4NADH	2ATP	4 Pyruvates
c	2NADH	2ATP	2 Pyruvates
d	ANADH	4ATP	4 Pyruvates

103. Which of the following does occur for the formation of acetyl Co-A from pyruvate:

a) Decarboxylation b) Carboxylation c) Hydrogenation d) Deamination

104. Pyruvic acid, end product of Glycolysis, before entering Krebs' cycle is changed into two carbon compound:

a) Citric acid b) Acetic acid c) Succinic acid d) α-Ketoglutaric acid

105. Acetic acid on entering the mitochondrion unites with co-enzyme-A to form:

a) Active acetate b) Pyruvic acid c) Fumarate d) α-Ketoglutaric acid

106. Conversion of one pyruvic acid into one acetyl CoA gives off one molecule of:
a) Citrate b) Pyruvate c) NADH d) ATP

107. First step in Krebs' cycle is union of acetyl Co-A with oxaloacetate to form:
a) Isocitrate b) α-Ketoglutaric acid c) Citrate d) Malate

108. At the beginning of Krebs' cycle acetyl Co-A combines with which substrate to form citrate (6-C):
a) Oxaloacetate b) Fumarate c) Oxoglutarate d) Succinate

109. The product of succinic acid by the action of enzyme is:
a) Fumaric acid b) Malonic acid c) Citric acid d) Pyruvic acid

110. The molecule of FADH2 is produced in Krebs' cycle during conversion of:
a) Fumarate to Malate b) Malate to Oxaloacetate c) Succinate to Fumarate d) Ketoglutarate to Succinate

111. From one pyruvate passing through Krebs' cycle how many FADH2 molecules are formed?
a) 1 b) 2 c) 3 d) 4

112. Number of oxidation steps during one Krebs' cycle is:
a) 1 b) 2 c) 3 d) 4

113. Total NADH formed by one glucose molecule during Krebs' cycle are:
a) 6 b) 8 c) 4 d) 18

114. In what stage of aerobic respiration are 2+ carbon molecules oxidized completely to carbon dioxide?
a) Glycolysis b) Krebs' cycle c) ETC d) Calvin cycle

115. In respiratory chain NADH is oxidized by:
a) Cytochrome b b) Coenzyme Q c) Oxygen d) None

116. In respiratory chain Coenzyme Q is oxidized by:
a) Cytochrome b b) Cytochrome a c) Oxygen d) Cytochrome c

117. Oxidative phosphorylation takes place in conjunction with the respiratory chain in the inner membrane of:
a) Mitochondria b) Chloroplast c) Golgi body d) Lysosome

118. The correct sequence of cytochrome, the electron transport intermediate in ETC is:
a) Cytochrome a → cytochrome b → cytochrome c → cytochrome a_3
b) Cytochrome b → cytochrome c → cytochrome a → cytochrome a_3
c) Cytochrome a → cytochrome a_3 → cytochrome b → cytochrome c
d) Cytochrome c → cytochrome b → cytochrome a3 → cytochrome a

119. During respiratory chain Coenzyme Q is oxidized by:
a) Cytochrome a b) Cytochrome b c) Cytochrome c d) Cytochrome d

120. In mitochondria the pumping of protons (Chemiosmosis) is across the:
a) Outer membrane b) Inner membrane c) Matrix d) Intermembranes space

121. The electron transport chain system plays role in generation of ATP by:
a) Photosynthesis b) Chemiosmosis c) Photosystem d) Dark reaction

122. Synthesis of ATP in the presence of oxygen is called:
a) Oxidative phosphorylation b) Photophosphorylation c) Chemiosmosis d) Fermentation

123. Which one of the following is not concerned with oxidative phosphorylation?
a) Coenzyme Q b) Cytochrome b c) Cytochrome a_3 d) Plastocyanin

124. The terminal electron acceptor in electron transport chain is:
a) Hydrogen b) CO_2 c) Cytochrome d) Oxygen

125. In which of the following life processes is ATP produced?
a) Photosynthesis only b) Aerobic respiration only c) Anaerobic respiration only d) All of these

Answer key:

1	c	**2**	c	**3**	b	**4**	a	**5**	d	**6**	a	**7**	c	**8**	b	**9**	c	**10**	b
11	b	**12**	a	**13**	c	**14**	d	**15**	a	**16**	c	**17**	c	**18**	b	**19**	d	**20**	a
21	a	**22**	c	**23**	d	**24**	b	**25**	c	**26**	a	**27**	c	**28**	c	**29**	a	**30**	c
31	d	**32**	b	**33**	b	**34**	a	**35**	b	**36**	c	**37**	c	**38**	d	**39**	c	**40**	c
41	b	**42**	c	**43**	b	**44**	b	**45**	c	**46**	a	**47**	a	**48**	d	**49**	a	**50**	d
51	c	**52**	c	**53**	c	**54**	a	**55**	b	**56**	d	**57**	c	**58**	b	**59**	a	**60**	b
61	b	**62**	a	**63**	c	**64**	d	**65**	b	**66**	c	**67**	b	**68**	a	**69**	d	**70**	d
71	d	**72**	a	**73**	b	**74**	b	**75**	b	**76**	b	**77**	a	**78**	c	**79**	d	**80**	d
81	a	**82**	d	**83**	a	**84**	c	**85**	c	**86**	c	**87**	b	**88**	d	**89**	c	**90**	b
91	b	**92**	c	**93**	c	**94**	d	**95**	b	**96**	d	**97**	c	**98**	c	**99**	d	**100**	b
101	b	**102**	a	**103**	a	**104**	b	**105**	a	**106**	c	**107**	c	**108**	a	**109**	a	**110**	c
111	a	**112**	a	**113**	a	**114**	b	**115**	b	**116**	a	**117**	a	**118**	b	**119**	b	**120**	b
121	b	**122**	a	**123**	D	**124**	a	**125**	a										

Prof. Ijaz Ahmad Khan Abbasi (Lecturer Biology PGC)

MDCAT MCQ'S

2008

1) In what stage of aerobic respiration are 2-carbon molecules oxidized completely to carbon dioxide?
a) Glycolysis b) Krebs cycle c) ETC d) Calvin cycle

2) Chlorophylls absorb mainly _____ wave length:
a) Yellow b) Violet-blue c) Green d) Indigo

3) Which form of anaerobic respiration occurs in muscle cell of humans and other animals during extreme physical activities?
a) Alcoholic fermentation b) Glycolysis c) Lactic acid fermentation d) Pyruvic acid oxidation

2009

4) Which of the following molecules is reduced by accepting hydrogen in Calvin Cycle?
a) Glyceraldehyde-3-phosphate
b) 3-Phosphoglycerate
c) Ribulose bisphosphate
d) 1,3-Bisphosphoglycerate

5) The molecule formed after first phosphorylation during glycolysis is:
a) Fructose-6-phosphate
b) Glucose-1-phosphate
c) Fructose-1, 6-bisphosphate
d) Glucose-6-phosphate

6) Krebs Cycle in mitochondria takes place in:
a) Cytosol b) Outer Membrane c) Matrix d) Inner Membrane

2010

7) Instrument which is used to measure relative abilities of different pigments to absorb different wavelengths of light is called:
a) Spectrometer b) Barometer c) Photometer d) Spectrophotometer

8) End products of yeast fermentation, bacterial fermentation and anaerobic respiration are:
a) Citric acid, lactic acid, carbon dioxide and water
b) Ethyl alcohol, lactic acid, carbon dioxide and water
c) Ethyl alcohol, citric acid and carbon dioxide
d) Methanol, lactic acid and citric acid

9) Krebs's cycle takes place in:
a) Ribosomes b) Mitochondria c) Golgi apparatus d) Endoplasmic Reticulum

2011

10) Oxidative phosphorylation, synthesis of ATP in the presence of oxygen occurs in:
a) All Types of Cells b) All Primitive Cells c) All Anaerobic Cells d) All Aerobic Cells

11) Glycolysis is the breakdown of glucose into two molecules of:
a) Glycerate b) Pyruvate c) Lactic Acid d) Succinic Acid

12) Before entering Krebs's cycle, the pyruvate is first decarboxylated and oxidized into:
a) Alpha Ketoglutaric Acid b) Glyceric Acid c) Citric Acid d) Acetic Acid

13) Some electron from the second primary acceptor may pass back to chlorophyll molecules by electron carrier system, yielding ATP. This process is called:
a) Phosphorylation b) Non-Cyclic Phosphorylation c) Photophosphorylation d) Cyclic Phosphorylation

14) Z-scheme is used for:
a) Non-Cyclic Photophosphorylation
b) Both Cyclic and Non-Cyclic Photophosphorylation
c) Cyclic Photophosphorylation
d) Oxidative Phosphorylation

2012

15) The product(s) of cyclic photophosphorylation is / are:
a) ATP b) NADP and ATP c) NADP d) NADP, ATP, and O_2

16) Total NADH formed by one glucose molecule during Krebs's Cycle are:
a) 6 b) 8 c) 3 d) 18

17) The terminal electron acceptor in electron transport chain is:
a) Hydrogen b) Cytochrome c) Iron d) Oxygen

18) The end product of glycolysis is:

a) ADP b) Citric acid c) Reduced FAD d) Pyruvate

19) One molecule of FADH2 is produced in Krebs's cycle during conversion of:

a) Fumarate Malate b) Malate Oxaloacetate c) Succinate Fumarate d) α-Ketoglutarate Succinate

2013

20) Every molecule of NADH, fed into ETC produces:

a) 2 ATP b) 4 ATP c) 3 ATP d) 6 ATP

21) Final acceptor of electrons in respiratory chain is:

a) Cytochrome a b) Cytochrome a_3 c) Oxygen d) Cytochrome c

22) The end product of anaerobic respiration in humans and other mammals is:

a) Pyruvic acid b) Lactic acid c) Ethanol d) Glucose

23) A biochemical process which occurs within a cell to breakdown complex compounds to produce energy is called:

a) Respiration b) Oxidation reduction c) Photosynthesis d) Photophosphorylation

24) Which part of chlorophyll molecule absorbs light?

a) Phytol b) Pyrrole c) Porphyrin ring d) Thylakoid membrane

2014

25) Oxidative phase of glycolysis starts with dehydrogenation of:

a) Glycolysis
b) Glyceraldehyde 3-phosphate
c) Ribulose Bisphosphate
d) NADH

26) In one turn, the Krebs's cycle produces one molecule of ATP, one molecule of FADH2 and_____ molecules of NADH:

a) 1 b) 3 c) 2 d) 4

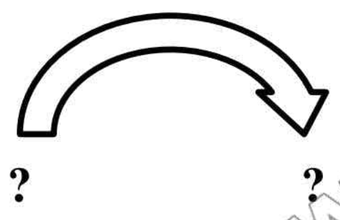
27) Which one of the following is the stage of cellular respiration for which oxygen is not essential?

a) Glycolysis b) Krebs's cycle c) Pyruvate oxidation d) Electron Transport Chain

28) Pyruvate, the end product of glycolysis moves from cytosol to mitochondrial matrix where it is oxidized into _____ producing CO_2 as a by-product:

a) Acetic acid (active) b) NAD c) Citrate d) FAD

29) Pyruvate Acetyl CoA



a) $FAD^+ \rightarrow FADH$
b) $NADH \rightarrow NAD + H^+$
c) $NAD^+ \rightarrow NADH$
d) $FADH^+ \rightarrow FAD + H^+$

2015

30) In light independent stage of photosynthesis, the CO2 combines with _____ to form an unstable 6-carbon intermediate:

a) Ribulose bisphosphate
b) Glycerate-3-phosphate
c) Hexose sugar
d) Glyceraldehyde-9-phosphate

31) In glycolysis, glycerate-1,3-bisphosphate is converted into glycerate-3-phosphate by losing _____ phosphate molecules:

a) 3 b) 1 c) 2 d) 4

32) Malate is oxidized by _____ to oxaloacetate in Krebs's Cycle:

a) ATP b) NAD c) NADP d) FAD

33) In electron transport chain, the electrons from NADH and FADH2 are passed to:

a) Cytochrome a b) Co-enzyme c c) Cytochrome a_3 d) Co-enzyme Q

34) Carriers of the respiratory chain are located on:

a) Matrix of mitochondria
b) Inner membrane of mitochondria
c) Outer membrane of mitochondria
d) Cytoplasmic matrix

2016

35) Each _____ consists of a light gathering antenna complex and reaction center:

a) Chlorophyll b) Photon c) Photosystem d) Electron

36) Photosystem I has chlorophyll a molecules which absorb maximum light of:

a) 680 nm b) 700 nm c) 780 nm d) 580 nm

37) Cyclic flow or C4 photosynthesis produces:

a) ATP and CO_2 b) Only CO_2 c) ATP d) Only Oxygen

38) Immediate product formed after CO_2 fixation in Calvin Cycle is:

a) Unstable 6-carbon compound
b) Unstable 4-carbon compound
c) Unstable 5-carbon compound
d) Unstable 3-carbon compound

39) Functional group of chlorophyll a is:

a) —CH3 b) —COOH c) —CHO d) —OH

2017

40) Chlorophyll molecule contains:

a) Mg^{++} b) K^{+} c) Ca^{++} d) Na^{+}

41) The tail of chlorophyll molecule is embedded in:

a) Membrane of mitochondria
b) Membrane of S.E.R
c) Thylakoid membrane
d) Membrane of R.E.R

42) Carotenoids absorb light of:

a) Yellow-orange range b) Orange-red range c) Yellow-red range d) Blue-violet range

43) Chlorophyll 'a' and chlorophyll 'b' differ in one of the functional groups .....Chlorophyll 'a' has:

a) –CHO b) -CH3 c) -OH d) -NH2

44) Glycerate-3-phosphate in the presence of ATP and reduced NADP from light dependent stage is reduced to:

a) 3-carbon compound b) 5-carbon compound c) Ribulose bisphosphate d) 6-carbon compound

45) Calvin cycle occurs in:

a) Grana of chloroplast
b) Chlorophyll(Reaction centre)
c) Stroma of chloroplast
d) Roots of plants

Answer key:

1	b	**2**	b	**3**	c	**4**	d	**5**	d
6	c	**7**	c	**8**	b	**9**	b	**10**	b
11	b	**12**	d	**13**	d	**14**	a	**15**	a
16	a	**17**	d	**18**	d	**19**	c	**20**	c
21	c	**22**	c	**23**	b	**24**	b	**25**	b
26	b	**27**	a	**28**	a	**29**	c	**30**	a
31	b	**32**	b	**33**	d	**34**	b	**35**	c
36	b	**37**	c	**38**	a	**39**	a	**40**	a
41	c	**42**	d	**43**	b	**44**	a	**45**	c

Exercise Short Answers

Q:1 List four features of leaf which show that it is able to carry out photosynthesis effectively.

Feature	Significance
Flatness of lamina	Maximum light absorption
Thickness of lamina	Deep penetration of light and efficient, rapid interval diffusion of gases (CO_2, O_2) throughout the leaf
Supported on petiole and green mosaic	Exposure to sunlight and air
Cuticle	Reduce loss of water by transpiration
Presence of stomata	Presence of stomata for the entry of CO_2
Vascular bundle	Highly vascular bundle for supply of water

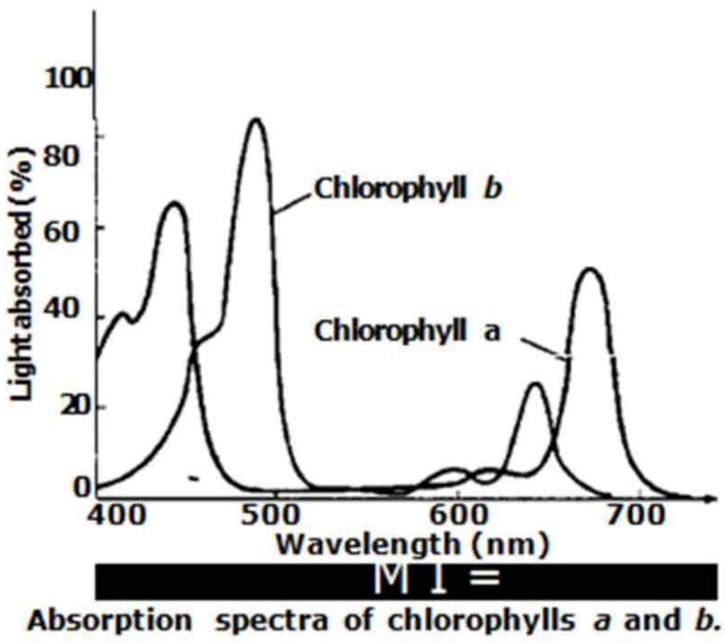
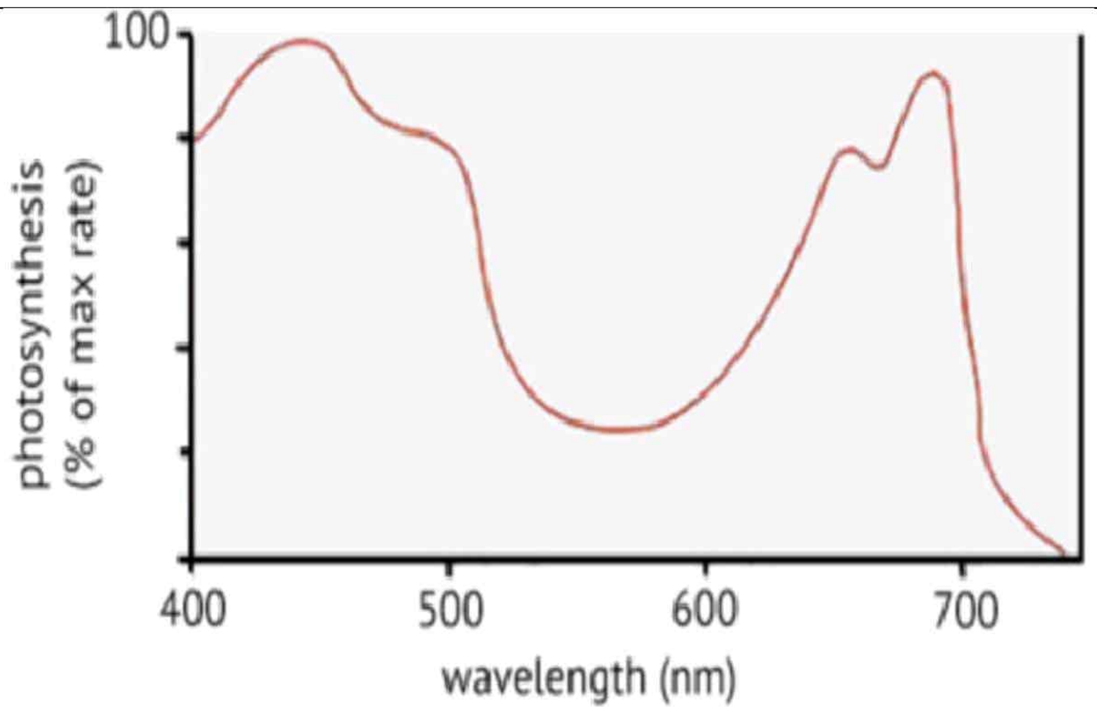
Q:2 How does light affect opening of stomata?

Ans: Guard cells are the only photosynthesizing cells of lower epidermis. So in the presence of light, photosynthesis starts and water is used. More water moves into guard cells form surroundings cells, they become turgid, and the inner thick walls bend outwards at the center, thus they produce an opening or pore. It would happen when osmotic potential of guard cells becomes less than that of surrounding epidermal cells. It means light is the driving force for opening of stomata.

Q:3 What causes the variation of osmotic potential in the guard cells?

Ans: Photosynthesis causes the variations of osmotic potential in the guard cells, by use and disuse of water. If photosynthesis is going on, water is being used causing an increase in osmotic potential and movement of water into guard cells. On the other hand when there is no photosynthesis, there will be no use of water so it accumulates in guard cells, thus decreasing osmotic potential and water may move out of the guard cells

Q:4 What is the difference between an action spectrum and absorption spectrum?

Absorption spectrum	Action spectrum
• A graph plotting absorption of light of different wavelength by a pigment is called absorption spectrum of the pigment. OR • The part of spectrum which is absorbed by the chlorophyll is called as absorption spectrum.	• Plot showing relative effectiveness of different wavelengths of light in arriving photosynthesis is called action spectrum of photosynthesis.
• The peaks represent the light that is absorbed by the pigment, while the valleys represent the light that is reflected or transmitted.	• Different wavelengths are not only differently absorbed by photosynthetic pigments but are also differently effective in photosynthesis.
• Peaks in absorption spectrum are less broad.	• Peaks in action spectrum are broader.
• Valley in absorption spectrum is deep.	• Valley in action spectrum is not so deep.
• Valley in absorption spectrum is more steep.	• Valley in action spectrum is less steep.
 Absorption spectra of chlorophylls *a* and *b*.	

Q:5 What is the role of accessory pigments in light absorption?

Ans: The accessory pigments absorb light and transfer the energy to chlorophyll "a" which then initiates the light reactions. Because accessory pigments absorb other wavelength of light which are not absorbed by chlorophyll.

Q:6 Difference between Cyclic and non-cyclic photophosphorylation.

Non-Cyclic photophosphorylation	Cyclic photophosphorylation
• In non-cyclic electron flow, electron does not return back to same excited chlorophyll.	• In cyclic electron flow, there is returning back of the same excited electrons to the excited chlorophyll by producing a molecule of ATP.
• Both photosystem II & I are involved in it.	• Only photosystem II is involved in it.
• End product of non-cyclic electron flow is ATP and NADPH.	• Only molecule of ATP is produced during non-cyclic electron flow.
• It is most common electron flow.	• It is less common electron flow.
• It regularly, supplies ATP and NADPH for photosynthesis.	• It is a short circuit to supply ATP.
• Oxygen is released	• Oxygen is not released

Q:7 What is the net production of ATP during glycolysis?

Ans: 2 ATP.

Q:8 What is the main difference between photo-phosphorylation and oxidative phosphorylation?

Ans: Synthesis of ATP in the presence of light is called photo-phosphorylation during light reaction of photosynthesis, while synthesis of ATP in the presence of oxygen is called oxidative phosphorylation by the breakdown of glucose and other related products.

Q:9 What is the location of ETC and chemiosmosis in photosynthesis and cellular respiration?

Ans: Thylakoid membranes in photosynthesis, and mitochondrial membranes in cellular respiration

Q:10 How did the evolution of photosynthesis affect the metabolic pathway?

Ans. With the emergence of photosynthesis on earth, molecular oxygen began to accumulate slowly in the atmosphere. The presence of free oxygen made possible the evolution of respiration. Respiration releases great deal of energy, and some of this energy is used in the formation of adenosine triphosphate (ATP) molecules. ATP is a kind of chemical link between catabolism and anabolism.

Q:11 How does absorption spectrum of chlorophyll a differ from that of chlorophyll b?

Ans. The molecular formula for chlorophyll a and b are:

- Chlorophyll A $C_{55}H_{72}O_5N_4Mg$
- Chlorophyll B $C_{55}H_{70}O_6N_4Mg$

Due to this slight difference in their structure, the two chlorophylls show slightly different absorption spectra and hence different colors. Some wave lengths not absorbed by chlorophyll a are very effectively absorbed by chlorophyll b and vice-versa. Such differences in structure of different pigments increase the range of wavelength of the light absorbed. Chlorophyll a is blue-green while chlorophyll b is yellow-green.

Q:12 Why are the carotenoids usually not obvious in the leaves? They can be seen in the leaves before leaf fall. Why?

Ans: The carotenoids are usually not obvious in the leaves as their yellowish color is covered by dark green color of chlorophyll. But just before leaf fall, the chlorophyll is destroyed and carotenoids can be seen.

Q:13 How is the formation of Vitamin A linked with eating of carrot?

Ans: Carrots contain carotenoids which are the precursors of vitamin A. This is why the formation of vitamin A is linked with eating of carrot.

Q:14 Summarize the role of water in photosynthesis.

Ans: water act as both reactant and the product of photosynthesis. It provides electrons from which energy is obtained that is needed for synthesis of glucose in dark reaction.

Q:15 What are T.W. Engelmann and Melvin Calvin famous for?

Ans: T.W. Engelmann first of all discovered action spectrum by experimenting on spirogyra while Melvin Calvin discovered the steps of dark reaction by using radioactive carbon dioxide.

Important Short Answers

Q:1 Differentiate between Chief and Accessory pigments.

Chief pigment	Accessory pigments
• Photosynthetic pigment is chlorophyll a. It is present in reaction center. It carries out Photolysis of water.	• The pigments which help the chlorophyll a for absorption of light of different wavelength are called accessory pigments.
• These are green pigment.	• Carotenoids are yellow and red to orange pigments.
• They absorb red and blue wavelength of light.	• They absorb strongly the blue-violet range of wavelengths. They absorb different wavelengths than the chlorophylls. In this way the spectrum of absorbed light is increased. Thus more energy is provided by photosynthesis.
• Chlorophyll a absorbs light absorbed by accessory pigment.	• Carotenoids and chlorophyll b absorb light and transfer the energy to chlorophyll a. This chlorophyll a then starts the light reaction. So carotenoids and chlorophyll b are called accessory pigments.

Q:2 Differentiate between Chlorophyll a and chlorophyll b.

	Chlorophyll a	Chlorophyll b
Molecular formula	$C_{55}H_{72}O_5N_4Mg$	$C_{55}H_{70}O_6N_4Mg$
Functional group	The functional group to the porphyrin is the methyl group (-CH3).	The functional group to the porphyrin is the carbonyl group (-CHO).
Occurrence	It is found in all photosynthetic organisms except photosynthetic bacteria	It is found with chlorophyll a in all green plants (embryophytes) and green algae.
Color	Blue-green	Yellow-green
Forms	Chlorophyll a has many forms which differ slightly in their red absorbing peaks (e.g., at 670,680,690,700 nm).	It has only one form.
Abundance	It is more abundant.	It is less abundant.
Type of pigment	Chlorophyll a initiates the light reactions.it is a chief pigment.	Chlorophyll b is the accessory pigment because it absorbs light and transfer the energy to chlorophyll a.

Q:3 What is stroma? Give its functions.

Ans: Stroma: The double membrane envelope encloses a dense fluid filled region called as stroma.

Function of stomata:

- The stoma has most of the enzymes which are involved in the production of carbohydrate molecules.
- Stomata are pores present in the epidermis of plants in large numbers, particularly in leaves, through which gaseous exchange takes place.

Q:4 Define the term bioenergetics.

Ans: Bioenergetics: The quantitatively study of energy relationships/transformation/conversion in biological systems is called bioenergetics.

- Biological energy transformations obey the law of thermodynamics.
- **Example:** The chloroplasts of the plants capture light energy coming from the sun and convert it into chemical energy. This chemical energy is stored in sugar and then in other organic molecules and animals uses this energy as food.

Q:5 Differentiate between Photosynthesis and Respiration.

Photosynthesis	Respiration
• It is the process in which solar energy is captured in the form of chemical energy (Carbohydrate).	• It is the process in which chemical energy of carbohydrate is released in the form of ATP.
• In this CO_2 and H_2O used to produce glucose in the presence of sun light.	• In this glucose is used to produce ATP, CO_2 and H_2O.
• It cannot take place in the absence of carbon dioxide.	• It may take place in the absence of oxygen.

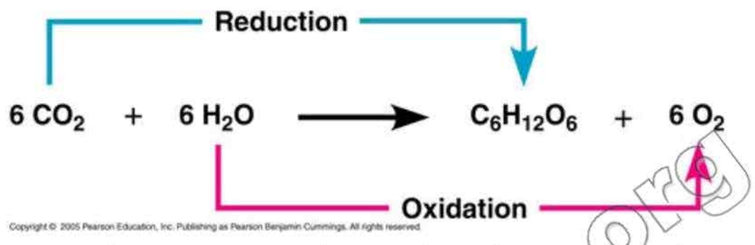
• Volume of carbon dioxide absorbed and oxygen released are always equal.	• Volume of carbon dioxide released and oxygen released may or may not be equal.
• Photosynthesis is an anabolic or constructive process.	• Respiration is catabolic or destructive process. In this case, glucose molecule is broken and energy is released.
• A plant gain weight due to photosynthesis.	• A plant losses its weight due to respiration.
• Photosynthesis takes place in chloroplast.	• Respiration takes place in mitochondrion.
• It occurs at day time only.	• It can occur at day and night time.
• It takes place in plants or green algae only.	• It takes place in all living organisms.

Q: 6 Define Photosynthesis with equation. What is redox reaction; give example.

Ans: Photosynthesis: it is the process in which energy poor inorganic oxidized compounds of carbon (CO_2) and hydrogen (mainly water) are reduced to energy-rich carbohydrates (sugar-glucose) using the light energy that is absorbed and converted into chemical energy by chlorophyll and some other photosynthetic pigments. OR

It is the process in which CO_2 and hydrogen (mainly hydrogen) are reduced to carbohydrates using the light energy that is absorbed and converted into chemical energy by chlorophyll and some other photosynthetic pigments.

- Photosynthesis is a redox reaction and can be summarized as follow:

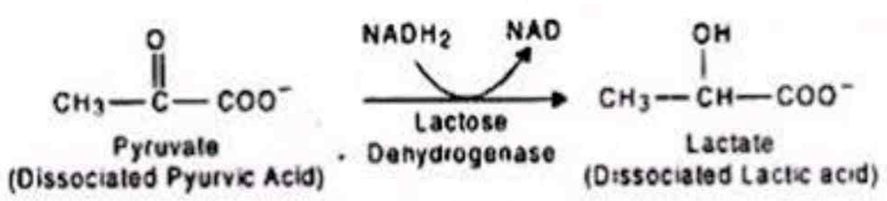
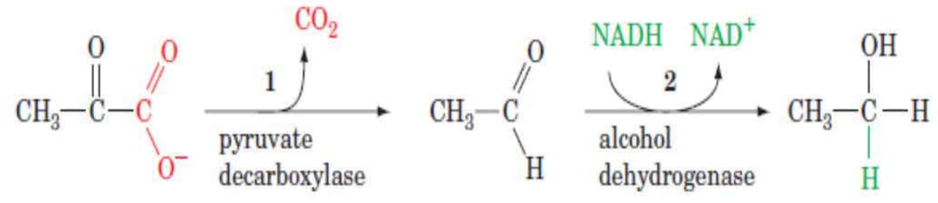


- However it is not a single step process. It is a complex process and completes in a series of reactions.

Q:7: Differentiate between aerobic and anaerobic respiration..

Aerobic respiration	Anaerobic respiration
• The respiration take place in the presence of oxygen is called aerobic respiration.	• The respiration take place in the absence of oxygen is called anaerobic respiration.
• In this case complete breakdown of glucose take place.	• In this case incomplete breakdown of glucose take place.
• The end product of areobic respiration are carbon dioxide and water.	• The end product of anerobic respiration are lactic acid and alcohol.
• It produces 36 molecules of ATP from one molecule of glucose.	• It produces only 2 molecules of ATP from one molecule of glucose.
• Areobic respiration is carried on in two stages called as glycolysis and Krebs' cycle.	• Anerobic respiration is also carried on in two stages called as glycolysis and fermentation.
• It takes place in cytosol and mitochondrion.	• It takes place only on cytosol.

Q:8: Differentiate between lactic acid and alcoholic fermentation.

Lactic acid	Alcoholic acid
• In this case, each pyruvic acid molecule is converted into lactic acid molecule.	• In this case, each pyruvic acid molecule is converted into alcohol and CO_2.
 Fig. 7.12 Lactic Acid Fermentation.	
• It occurs in muscles cells of human and other animals.	• It occurs in primitive cell or simple eukaryotes like yeast.
• It takes place during extreme physical activities like sprinting. When oxygen cannot be transported to the cell during such extreme activities. Therefore, pyruvic acid is changed into lactic acid.	• It takes in special types of anaerobic bacteria and yeast.

Q:9 Differentiate between reaction center and antenna complex.

Reaction center	Antenna complex
• It is part of photosystem where light energy is converted into chemical energy.	• It is part of photosystem where light energy is absorbed and channeled the energy to reaction center.
• Reaction center has one or more molecules of chlorophyll a.	• The antenna complex has many molecules f chlorophyll a, chlorophyll b, and carotenoids.
• It is linked with primary electron acceptor and electron transport system.	• It is not linked with primary electron acceptor and electron transport system.
• **Examples:** reaction center two types P-680 and P-700.	• **Examples:** Antenna complex has many types depending on pigments.

Q:10 Sum up how much energy (as ATP) is made available to cell from a single glucose molecule by the operation of glycolysis, the formation of acetyl CoA the citric acid cycle, and the electron transport chain.

Ans: For each glucose molecule that is completely broken down to CO2 and H2O molecules by the sequential actions of glycolysis, the Krebs cycle, and respiratory electron transport, 38 ATP molecules can be formed. 2 ATP molecules are obtained during glycolysis, 2 during Krebs cycle and 34 during respiratory chain.

Q:11 What are the roles of the following in aerobic respiration: (a) NAD and FAD (b) Oxygen.

Ans. NAD and FAD are the co-enzymes which help enzymes to carry out the reactions during aerobic respiration, whereas oxygen accepts the H atoms and make water in the last step of respiratory chain.

Q:12 How NADH and ATP can inhibit cellular respiration.

Ans: ATP is the negative regulator of phosphofructokinase, which makes sense; if there is already plenty of ATP in the cell, glycolysis does not need to make more. Therefore, high concentration of ATP will inhibit phosphofructokinase. Similarly NADH is negative regulator of pyruvate decarboxylase which means that if more NADH then it will inhibit pyruvate decarboxylase.

Q:13 Differentiate between photophosphorylation and oxidative phosphorylation.

Photophosphorylation	Oxidative phosphorylation
• Synthesis of ATP in the presence of light is called photo-phosphorylation.	• Synthesis of ATP in the presence of oxygen is called oxidative phosphorylation
• It occurs during photosystem.	• It occurs during respiration.
• It takes place in thylakoid membranes chloroplast.	• It takes place in inner mitochondrial membrane.
• It occurs only in plant cells.	• It occurs in plant and animal both cells.

Q:14 What is compensation point?

Ans: Compensation point: The light intensity at which the net gaseous exchange is zero is called compensation point. OR

The point where there is no net gas exchange between leaves and atmosphere at dawn and dusk is called compensation point.

- At this point rate of respiration becomes equal to rate of photosynthesis in plants.
- At dawn (early morning) and dusk (early evening) when light intensity is low, the rate of photosynthesis and respiration are equal for a short time. This is because that the oxygen released from the photosynthesis is used in cellular respiration. Similarly the carbon dioxide released by respiration is used by respiration is used in photosynthetic process. At this moment there is no net gas exchange between the leaves and the environment.

Q:15 Define chemiosmosis.

Ans: Chemiosmosis: Pumping of H+ (during photosynthesis) by the electron transport chain across the membrane of thylakoid into the stroma to produce ATP is called chemiosmosis. OR

It is the process that uses thylakoid membranes for redox reactions to produce ATP.

- The electron transport carries use energy of electrons energy to produce ATP and NADPH are produced on stroma side surface of the thylakoid.
- ETC pumps additional H+ across the membrane of the thylakoid and ATP synthase energy.
- In both cyclic and non-cyclic phosphorylation, the mechanism for ATP synthesis is chemiosmosis.

Q:16 What are cytochrome?

Ans: Cytochrome: Cytochromes are electron transport intermediates. These contain haem of related prosthetic group that changes valency of iron atom. Haem is the same iron containing oxygen carrying pigment group that is in hemoglobin. For example cytochrome b, c, a etc.

Q:17 What is meant by bacteriochlorophylls?

Ans: Bacteriochlorophylls: Bacteriochlorophylls are the pigments in bacterial membrane systems that upon excitement by light lose electrons and initiate photosynthetic reactions.

- They are different from the pigments found in higher plants and algae
- **Example**: Bacteriochlorophyll a and b are found in green Sulphur bacteria which do not use water as a source of hydrogen ions in production of carbohydrate in the dark reaction, instead they use H2S as a hydrogen ion source and convert the hydrogen sulfide to sulfur. Consequently no oxygen is liberated.

Q:18 What do you know about Rubisco?

Ans: Rubisco:

1) It is abbreviated form of Ribulose Bisphosphate Carboxylase/Oxygenase.
2) It is an enzyme in the stroma of chloroplasts that usually behaves as RUBP carboxylase but under some environmental conditions it can behave as RUBP oxygenase instead of carboxylase.
3) As carboxylase, it is a key enzyme that catalyzes the first reaction in the metabolic pathway leading to the reduction of CO_2 in the dark reactions of photosynthesis.
4) It is most abundant protein in the chloroplasts and probably the most abundant protein on earth.

Q:19 What is pay off phase of glycolysis.

Ans: Pay off phase of glycolysis:

1) It is also known as oxidative phase of glycolysis.
2) During this phase NAD+ accepts electrons and hydrogen to form NADH + H^+.
3) High energy phosphate bonds are formed and energy is stored in the form of ATP.

Q:20 Differentiate between Photosystem I or photosystem II.

Photosystem I or PSI or P700	Photosystem II or PSII or P680
• It is located mainly in non-stacked thylakoids.	• It is present in stacked membranes of grana.
• It is found in plants, algae, cyanobacteria and photosynthetic bacteria.	• It is absent in photosynthetic bacteria.
• It consist of primary acceptor, chlorophyll a and accessory pigments.	• It contains chlorophyll a, b and accessory pigments.
• It absorb light about 700nm, hence it is called P700 where P stands simply for pigment.	• It absorb only short wavelength of red light primarily at 680nm hence is called P680.

Q:21 How it was proved that the source of oxygen in photosynthesis is water?

Ans: Source of O_2 in photosynthesis: In order to prove that the source of oxygen in photosynthesis is water scientists used water and carbon dioxide containing heavy oxygen isotope O^{18}.

- **Experiment 1:** Experimental green plants in one group were supplied with H_2O containing O^{18} and CO_2 containing only common oxygen O^{16}.
- **Experiment 2:** Plants in second group were supplied with H_2O containing only common oxygen O^{16} but CO_2 containing O^{18}.
- **Conclusion:** It was found that plants of first group produced O^{18} and plants of second group did not.

Expt 1: Photosynthesis in the presence of isotopic water

$$CO_2 \text{ (Carbon dioxide)} + 2H_2O^{18} \text{ (Heavy Water)} \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 \text{ (Glucose)} + H_2O \text{ (Water)} + O_2{}^{18} \text{ (Isotopic oxygen)}$$

Expt 2: Photosynthesis in the presence of isotopic carbon dioxide

$$CO_2{}^{18} \text{ (Carbon dioxide)} + 2H_2O \text{ (Water)} \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6{}^{18} \text{ (Glucose)} + H_2O^{18} \text{ (Heavy Water)} + O_2 \text{ (Oxygen)}$$

Q:22 Name main parts of chlorophyll molecule; what is porphyrin ring.

Ans: A chlorophyll molecule has two main parts which are head and tail.

1) **The head:**
   - It is a flat, square light absorbing and hydrophilic.
   - It is complex porphyrin ring which is made up of 4 joined smaller pyrrole rings. These rings are composed of carbon and nitrogen atoms.
   - An atom of magnesium is present is present in the center of porphyrin rings.

2) Tail:

- The tail is made up of long chain of hydrocarbons called phytol.
- It is anchoring and hydrophobic and is attached to one of pyrrole rings.
- The chlorophyll molecule is embedded in the hydrophobic core of thylakoid membrane by this tail.

Q:23 Differentiate between light dependent and light independent reaction.

Light dependent reaction	Light independent reaction
• They take place in the thylakoid membranes inside the chloroplast (grana of chloroplast).	• They take place within the stroma of chloroplast.
• The material needed for light dependent reactions are excited electrons, water, a number of electron carrier molecules and $NADP^+$.	• The materials needed for the light independent reactions are ATP, NADPH, CO_2 and a 5-carbon starter molecule called ribulose.
• The products are O_2, NADPH and ATP.	• The products are glyceraldehydes-3-phosphate, $NADP^+$, ADP, P and ribulose.
• The activities of light dependent reaction can be summarized as follows: Excited electrons + H_2O + ADP + $NADP^+ \rightarrow$ ATP + NADPH + O_2	• The activities of light independent reaction can be summarized as follows: ATP + NADPH + ribulose + $CO_2 \rightarrow$ ADP + $NADP^+$ + complex organic molecule + ribulose.