

# PHOTOSYNTHESIS IN HIGHER PLANTS

- As compared to a  $C_3$ -plant, how many additional molecules of ATP are needed for net production of one molecule of hexose sugar by  $C_4$ -plants?  
a) 2                                      b) 6                                      c) 0                                      d) 12
- Proton gradient is broken down due to  
a) Movement of electrons across the membrane to stroma  
b) Movement of electrons across the membrane to lumen  
c) Movement of proton across the membrane to lumen  
d) Movement of proton across the membrane to stroma
- Which of the following is a simplified equation of photosynthesis?  
a)  $CO_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} C_5H_{10}O_4 + H_2O + O_2 \uparrow$       b)  $CO_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} (CH_2O)_n + O_2 \uparrow$   
c)  $CO_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} C_3H_6O_3 + CO_2 + O_2 \uparrow$       d)  $CO_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} (CH_2O)_n + H_2O + O_2 \uparrow$
- The membrane of thylakoid is called  
a) Cell membrane                                      b) Fret membrane  
c) Granum membrane                                      d) Thylakoid membrane
- The enzyme responsible for primary carboxylation in  $C_3$ -plants is  
a) Hexokinase                                      b) Succinic dehydrogenase  
c) Pyruvate carboxylase                                      d) RuBP carboxylase oxygenase
- The law of limiting factors was proposed with particular reference to photosynthesis. Identify the scientist, who proposed this law?  
a) Calvin                                      b) Weismann                                      c) Emerson                                      d) Blackman
- The synthesis of one molecule of glucose during Calvin cycle requires  
a) 12 molecules of ATP and 18 molecules of  $NADPH_2$   
b) 6 molecules of ATP and 12 molecules of  $NADPH_2$   
c) 18 molecules of ATP and 12 molecules of  $NADPH_2$   
d) 12 molecules each of ATP and  $NADPH_2$
- The enzymatic reactions incorporate  $CO_2$  into the plants leading to the synthesis of sugar in  
a) Stroma                                      b) Stroma lamella                                      c) Grana                                      d) Both (a) and (b)
- In CAM-plants, carbon dioxide acceptor is  
a) RuBP                                      b) PEP                                      c) OAA                                      d) PGA
- PEP carboxylase  
I. is involved in atleast some  $CO_2$  fixation in both  $C_3$  and  $C_4$ -plants  
II. Catalyses the reaction of fixing  $CO_2$  into pyruvic acid in bundle sheath cells  
III. is capable of fixing  $CO_2$  more efficiently at lower atmospheric  $CO_2$  concentration than RuBP carboxylase  
Select the correct option  
a) I and II                                      b) II and III                                      c) I, II and III                                      d) Only III
- Which factor is not limiting in normal condition for photosynthesis?  
a) Air                                      b) Carbon dioxide                                      c) Water                                      d) Chlorophyll
- PS is made up of which of the following?  
a) Reaction centre                                      b) Antenna molecule

c) Both (a) and (b)

13. In higher plants, the shape of the chloroplast is

- a) Discoid                                      b) Cup-shaped

d) Reaction centre and H<sub>2</sub>O

- c) Girdle-shaped                              d) Reticulate

14. Identify the correct combination of the following

substrate	enzyme	Product
I. Phosphoenolpyruvate	PEP carboxylase	C <sub>4</sub> acid
II. Malate	Malic enzyme	C <sub>4</sub> acid
III. RuBP	Ribulose 5-phosphate kinase	C <sub>3</sub> acid
IV. Pyruvate	Pyruvate dikinase	C <sub>3</sub> acid

- a) III and IV                                      b) I and II

c) II and III

d) I and IV

15. Cyclic photophosphorylation produces

- a) NADPH                                      b) ATP

c) ATP + NADPH<sub>2</sub>

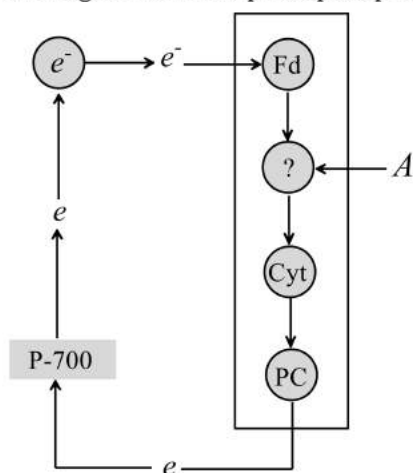
d) ATP + NADPH<sub>2</sub> + O<sub>2</sub>

16. Phenomenon which converts light energy into chemical energy is

- a) Respiration                                      b) Photosynthesis                                      c) Transpiration

d) None of these

17. In the given chart of photophosphorylation. What does 'A' represent?



a) PC

b) FRS

c) PQ

d) Cyt -a<sub>3</sub>

18. In photosystem, antennae includes all pigments except

- a) Chlorophyll-a                                      b) Chlorophyll-b                                      c) Carotenoids

d) Xanthophyll

19. I. Tomato  
II. Black pepper  
III. Mango

From the above option choose the correct answer in respect of green house crops

- a) I and III                                      b) III and II                                      c) I, II and III                                      d) I and II

20. Plastocyanin contains

- a) Copper                                      b) Iron                                      c) Calcium                                      d) potassium

21. The two pigment system theory of photosynthesis was proposed by

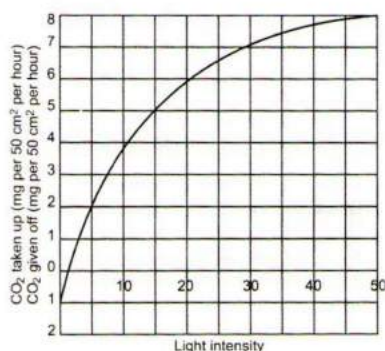
- a) Blackman                                      b) Hill                                      c) Emerson                                      d) Arnon

22. Which one of the following is not true about the light reactions of photosynthesis?

- a) Light energy provides energy for the photolysis of water through excitation of the reaction centre of PS-II  
b) The flow of electrons from water to NADP in non-cyclic electron transport produces one ATP

- c) Reactions of the two photosystems are needed for the reduction of NADP  
 d)  $P_{680}$  and  $P_{700}$  are the reaction centres of PS-I and PS-II respectively
23. By which plant pigment maximum absorption of radiation takes place in the blue and red regions of absorption spectrum?  
 a) Chlorophyll-*a*      b) Chlorophyll-*b*      c) Xanthophyll      d) Carotenoid
24. Factors affecting photosynthesis are  
 I. number and size of leaves  
 II. age and orientation of leaves  
 III. amount of chlorophyll  
 IV. amount of  $O_2$  and  $CO_2$   
 Select the correct option  
 a) I, II and IV      b) II, IV and V      c) IV, V and I      d) I, II, III and IV
25. In an experiment, a leaf was partially covered with black paper, and other one was exposed to light. On testing these leaves for starch, in the presence of sunlight, one may conclude that photosynthesis had occurred in  
 a) Green part of leaves      b) Black paper covered part of leaves  
 c) Both (a) and (b)      d) None of the above
26. I. It is the characteristic of  $C_4$ -plants  
 II. It is the characteristic of  $C_3$ -plants  
 III. It occurs in chloroplast  
 IV. It occurs in day time  
 V. It occurs in night  
 Select the correct options in relation to photorespiration  
**Correct option    Incorrect option**  
 a) I, IV      II, III, IV      b) II, III, IV      I, V  
 c) I, II, III      IV, V      d) IV, V      I, II, III
27. First reaction in photosynthesis is  
 a) Photolysis of water      b) Excitation of chlorophyll molecule  
 c) Formation of APT      d) Fixation of  $CO_2$
28. Kranz anatomy is a morphological diversity in the leaves of  
 a)  $C_3$ -plants      b)  $C_4$ -plants      c) Both (a) and (b)      d) CAM-plants
29. Which of the following is concerned with carbon dioxide fixation?  
 a) Krebs cycle      b) Calvin cycle      c) Ornithine cycle      d) Glycolysis
30. Hill reaction occurs in  
 a) High altitude plants      b) Total darkness  
 c) Absence of water      d) Presence of ferricyanide
31. Rubisco enzyme is absent in  
 a) Mesophyll cell      b) Bundle sheath cell      c)  $C_3$ -plants      d)  $C_4$ -plants
32. During the experiment in laboratory, the thylakoid is somehow punctured so that the interior of the thylakoid is no longer separated from stroma. This damage will have the direction effect on  
 a) ATP formation      b) Absorption of light  
 c) Flow of electrons from PS-I to PS-II      d) All of the above
33. The graph below shows the relation between light intensity and the giving off and taking up of carbon dioxide by the leaves of a plant. Why is most carbon dioxide given off when the light intensity is zero units?



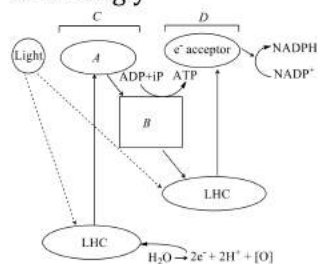


- a) Because it is just the start of the experiment  
 b) Only respiration is taking place at this intensity of light  
 c) Only photosynthesis is taking place at this intensity of light  
 d) The rate of photosynthesis is equivalent to the rate of respiration
34. Cyclic photophosphorylation results only in the  
 a) Formation of ATP  
 b) Formation of NADP<sup>+</sup> + H<sup>+</sup> and ATP  
 c) Formation of NAD<sup>+</sup> + H<sup>+</sup>  
 d) Formation of ADP + Pi
35. I. H<sub>2</sub>S not H<sub>2</sub>O is involved in photosynthesis of sulphur bacteria  
 II. ATP is produced during light reaction *via* chemiosmosis  
 III. Absence of light leads to the stoppage of photosynthesis  
 IV. Calvin cycle occurs in grana  
 Select the correct option  
 a) II, III and IV  
 b) I, III and IV  
 c) I, II and IV  
 d) I, II and III
36. Under normal condition, which one of the following is a major limiting factor?  
 a) Light  
 b) CO<sub>2</sub>  
 c) Temperature  
 d) Chlorophyll
37. Which one is essential for the respiration as well as photosynthesis?  
 a) Rubisco  
 b) Plastocyanin  
 c) Ubiquinone  
 d) Cytochrome
38. Light Harvesting Complex (LHC) is  
 a) One molecule of chlorophyll-*a*  
 b) Very few molecule of chlorophyll-*a*  
 c) Hundreds of pigment molecules bound to proteins  
 d) Chlorophyll-*a* + chlorophyll-*c* + protein + DNA
39. Which of the following represents the correct molecular formula of chlorophyll-*b*?  
 a) C<sub>55</sub>H<sub>72</sub>O<sub>6</sub>N<sub>4</sub>Mg  
 b) C<sub>55</sub>H<sub>72</sub>O<sub>5</sub>N<sub>4</sub>Mg  
 c) C<sub>55</sub>H<sub>72</sub>O<sub>4</sub>N<sub>4</sub>Mg  
 d) C<sub>55</sub>H<sub>70</sub>O<sub>6</sub>N<sub>4</sub>Mg
40. In C<sub>4</sub>-plants, the bundle sheath cells  
 a) Have thin walls to facilitate gaseous exchange  
 b) Have large intercellular spaces  
 c) Are rich in PEP carboxylase  
 d) Have a high density of chloroplasts
41. The following (I-IV) are the main steps of chemosynthetic ATP synthesis in the light reaction. Arrange them in correct order  
 I. H<sup>+</sup> concentration gradient established  
 II. H<sup>+</sup> diffuses through ATP synthetase  
 III. Carriers use energy from electrons to move H<sup>+</sup> across the membrane  
 IV. Electrons from PS-II pass along electron transport chain  
 V. Light excites electrons in PS-II  
 VI. Energy of H<sup>+</sup> flow is used by ATP synthetase to make ATP  
 a) I, II, III, IV, V, VI  
 b) II, IV, V, III, I, VI  
 c) V, IV, III, I, II, VI  
 d) V, VI, III, IV, II, I
42. What is the wavelength of radiations in visible spectrum?  
 a) 400-700 nm  
 b) 400-800 nm  
 c) 390-760 nm  
 d) 760-390 nm
43. Which of the following is not related to photorespiration?  
 a) Lysosome  
 b) Chloroplast  
 c) Peroxisome  
 d) Mitochondria
44. The internal factors that affects photosynthesis of plant depends on the



- a) Morphological predisposition  
c) Temperature
- b) Genetic predisposition  
d) Environment predisposition
45. How many H<sup>+</sup> ions are formed from 12 water molecules during non-cyclic photophosphorylation?  
a) 12                                      b) 24                                      c) 36                                      d) 48
46. In non-cyclic photophosphorylation, there is photolysis of 12 water molecules. How many H<sup>+</sup> are formed?  
a) 24 H<sup>+</sup>                                      b) 36 H<sup>+</sup>                                      c) 12 H<sup>+</sup>                                      d) 32 H<sup>+</sup>
47. Maximum photosynthesis occurs in  
a) Red light                                      b) Blue light                                      c) Green light                                      d) Violet light
48. I. Initial CO<sub>2</sub> acceptor  
II. Extent of photorespiration  
III. Enzyme catalysing reaction that fixes CO<sub>2</sub>  
IV. Presence of Calvin cycle  
V. Leaf anatomy  
Which one does not differ in a C<sub>3</sub> and C<sub>4</sub>-plants?  
a) I and V                                      b) Only IV                                      c) II and III                                      d) Only II
49. Energy transfer in photosynthesis occurs as  
a) Phycoerythrin → phycocyanin → carotenoid → chlorophyll-a  
b) Chlorophyll-b → carotenoid → phycoerythrin → chlorophyll-a  
c) Phycocyanin → phycoerythrin → carotenoid → chlorophyll-a  
d) Chlorophyll-b → carotenoid → phycocyanin → chlorophyll-a
50. What is true for photosynthesis?  
a) Carbon dioxide is oxidised and water is reduced  
b) Carbon dioxide is reduced and water is oxidised  
c) Both carbon dioxide and water are reduced  
d) Both carbon dioxide and water are oxidised
51. Which of the following statement is false in case of (C<sub>4</sub>-plant)?  
a) CO<sub>2</sub> acceptor is RuBisCo in mesophyll cell  
b) Carboxylation occurs in mesophyll cells  
c) Leaves have two cell types  
d) Mesophyll cells lack Rubisco
52. Chlorophyll in chloroplasts is located in  
a) Grana                                      b) Pyrenoid                                      c) Stroma                                      d) Both (a) and (b)
53. Which photosystem is involved in cyclic photophosphorylation?  
a) PS-II                                      b) PS-I  
c) Xanthophyll and PS-II                                      d) Xanthophyll and PS-I
54. The mechanism of ATP formation both in chloroplast and mitochondria is explained by  
a) Relay pump theory of Godlewski                                      b) Cholodny-Went's model  
c) Chemiosmotic theory                                      d) Munch's mass-flow hypothesis
55. Absorption spectrum of chlorophyll-a and the action spectrum of photosynthesis is identical because chlorophyll-a  
a) Absorbs the maximum light                                      b) Absorbs the minimum light  
c) Absorbs the red and blue light                                      d) Is found most abundantly
56. Which would do maximum harm to a tree?  
a) Loss of half of its branches                                      b) Loss of all its bark  
c) Loss of all its leaves                                      d) Loss of half of its leaves
57. Pyruvate + ATP  $\xrightarrow{y}$  PEP + AMP + H<sub>3</sub>PO<sub>4</sub>  
Identify-y in the given reaction and choose the correct option  
a) Phosphopyruvate dikinase                                      b) Phosphopyruvate monokinase  
c) Phosphopyruvate dikinase                                      d) Phosphopyruvate dehydrogenase
58. A wastage process is

- a) Respiration                      b) Photosynthesis                      c) Photorespiration                      d) Movement
59. How many molecules of glycine is required to release one CO<sub>2</sub> molecule in photorespiration?  
a) One                      b) Two                      c) Three                      d) Four
60. Choose the correct statement.  
a) The C<sub>4</sub>-plants do not have RUBISCO  
b) Carboxylation of RuBP leads to the formation of PGA and phosphoglycolate  
c) Carboxylation of phosphoenol pyruvate results in the formation of C<sub>4</sub>-plants  
d) Decarboxylation of C<sub>4</sub>-acids occur in the mesophyll cells
61. Conditions helpful in photorespiration are  
a) More oxygen and less carbon dioxide                      b) Less oxygen and more carbon dioxide  
c) More temperature and less oxygen                      d) More humidity and less temperature
62. Which of the following is/are the raw material for photosynthesis?  
I. H<sub>2</sub>O    II. CO<sub>2</sub>  
III. Light    IV. Chlorophyll  
Choose the correct option  
a) II, III and IV                      b) I and IV                      c) I, II and III                      d) I, II, III and IV
63. The special structure present in C<sub>4</sub>-plants in  
a) Thin cuticle                      b) Multi-layered epidermis  
c) Kranz type body                      d) One-layered epidermis
64. In which of the following form glucose is usually stored in plants?  
a) Lipid                      b) Carbohydrates                      c) Protein                      d) Starch
65. A student sets up an experiment on photosynthesis as follow : He takes soda water in a glass tumbler and add a chlorophyll extracts into the contents and keeps the tumbler exposed sunlight hoping that he has provided necessary ingredient for photosynthesis to proceed (viz, CO<sub>2</sub>, H<sub>2</sub>O, chlorophyll and light). What do you think what will happen after, say few hours of exposure of light?  
a) Photosynthesis will take place and glucose will produced  
b) Photosynthesis will take place and starch will be produced which will turn the mixture turbid  
c) Photosynthesis will not take place because CO<sub>2</sub> dissolves in soda water escapes into the atmosphere  
d) Photosynthesis will not take place because intact chloroplasts are needed for the process
66. With respect to compensation point, which of the following is true for C<sub>3</sub> and C<sub>4</sub>-plants  
a) Compensation points of C<sub>3</sub> and C<sub>4</sub>- plants are equal  
b) Compensation points of C<sub>3</sub>- plant is higher than C<sub>4</sub>-plants  
c) Compensation points of C<sub>4</sub>-plant is higher than C<sub>3</sub>-d) plants
67. Light energy in photosynthesis is utilized in  
a) H<sub>2</sub>O converted into H<sub>2</sub>                      b) ADP converted into ATP  
c) ATP converted into ADP                      d) None of the above
68. Identify A, B, C and D in the given diagram of z-scheme of light reaction and choose the correct option accordingly



- a) A-e<sup>-</sup> acceptor, B-ETS, C-PS-II, D-PS-I                      b) A-e<sup>-</sup> acceptor, B-ETS, C-PS-I, D-PS-II  
c) A-ETS, B-e<sup>-</sup> acceptor, C-PS-I, D-PS-II                      d) A-ETS, B-e<sup>-</sup> acceptor, C-PS-II, D-PS-I
69.  $PEP + CO_2 + H_2O \xrightarrow{x} \text{Oxaloacetic acid} + H_3PO_4$



- Identify X
- a) Ligase                      b) Oxidoreductase                      c) PEP carboxylase                      d) Lyase
70. Stroma lamellae membrane lacks  
I. PS-II  
II. NADP reductase  
III. non-cyclic photophosphorylation  
Select the correct option  
a) I and II                      b) II and III                      c) III and I                      d) I, II and III
71. RUBISCO stands for  
a) Ribulosebisphosphate carboxylase oxygenase  
b) Ribulose phosphate carboxylase oxygenase  
c) Ribulose phosphate carboxylic oxygenase  
d) None of the above
72. In chloroplasts, chlorophyll is present in the  
a) Outer membrane                      b) Inner membrane                      c) Thylakoids                      d) stroma
73. DCMC  
a) Inhibits PS-I  
b) Inhibits PS-II  
c) Destroy chloroplast  
d) Inhibits oxidative phosphorylation
74. Malic acid (4-C) is produced in which plant without Kranz anatomy?  
a) *Bryophyllum*                      b) *Kalanchoe*                      c) *Opuntia*                      d) All of these
75. What is the advantage of light reactions producing ATP and NADPH<sub>2</sub> on stromal side of thylakoid membrane?  
a) Calvin cycle consumes ATP and NADPH<sub>2</sub> from stroma  
b) Light reaction occurs in stroma  
c) Dark reaction occurs in grana need ATP + NADPH<sub>2</sub>  
d) CO<sub>2</sub> is produced in stroma
76. Generally, plants adapted to dry tropical conditions have  
a) C<sub>2</sub> pathway                      b) C<sub>3</sub> pathway                      c) C<sub>5</sub> pathway                      d) C<sub>4</sub> pathway
77. Correct sequence of rate of photosynthesis in different light is  
a) Red > Blue > Green                      b) Blue > Red > Green                      c) Green > Blue > Red                      d) Green > Red > Blue
78. During the light reaction, the water splits into  
a) H<sup>+</sup>, O<sub>2</sub> electrons                      b) H<sub>2</sub>, O<sub>2</sub> electrons                      c) 2H<sup>+</sup>,  $\frac{1}{2}$ O<sub>2</sub> 2 electrons                      d)  $\frac{1}{2}$ H<sub>2</sub>,  $\frac{1}{2}$ O<sub>2</sub> electrons
79. Adenosine diphosphate contains  
a) One high energy bonds                      b) Two high energy bonds  
c) Three high energy bonds                      d) Four high energy bonds
80. The thylakoids are aggregated to form stalks of discs called  
a) Stroma                      b) Grana  
c) Stroma thylakoids                      d) Intergranal thylakoids
81. Which hypothesis best explains the synthesis of ATP in chloroplast?  
a) Chemosynthetic hypothesis                      b) Chemiosmotic hypothesis  
c) Potential gradient hypothesis                      d) Redox gradient hypothesis
82. In dark cycle, one molecule of glucose formation needed  
a) 12 ATP and 12 NADPH                      b) 14 ATP and 12 NADPH  
c) 16 ATP and 12 NADPH                      d) 18 ATP and 12 NADPH
83. The main photosynthetic pigments in the plants are  
a) Chlorophyll-*a* and chlorophyll-*c*                      b) Chlorophyll-*a* and chlorophyll-*d*  
c) Chlorophyll-*b* and chlorophyll-*a*                      d) Chlorophyll-*b* and chlorophyll-*c*



84. Radioactive  $C^{14}$  is given to carbon dioxide and released to atmosphere. This carbon dioxide is taken by RuBP in a  $C_3$ -plants. First radioactive  $C^{14}$  is seen, in which compound?  
 a) PGAL                      b) PEP                      c) RMP                      d) PGA
85. Example of water soluble plant pigment is  
 a) Chlorophyll- $\alpha$               b) Chlorophyll- $\beta$               c) Anthocyanin              d) xanthophyll
86. PS-I and PS-II were discovered by  
 a) Robert Emerson              b) Blackman              c) Robert Mayer              d) Arnon
87. Photorespiration is also called  
 I. Glycolate pathway  
 II.  $C_3$ -cycle  
 III. Oxidative photosynthetic carbon cycle  
 Select the correct option  
 a) I and II                      b) II and III                      c) III and I                      d) I, II and III
88. 'Hatch and Slack' cycle is found in  
 a)  $C_4$ -plants                      b)  $C_3$ -plants                      c) Both (a) and (b)              d) None of these
89. Which of the following statements is true with regard to light reaction of photosynthetic mechanism in plants?  
 a) Chlorophyll- $\alpha$  occurs with peak absorption at 680 nm in photo system-I and at 700 nm in photo system-II  
 b) Magnesium and sodium ions are associated with photolysis of water molecules  
 c)  $O_2$  is evolved during cyclic photophosphorylation  
 d) Photo system-I and II are both involved in non-cyclic photophosphorylation
90. Photosynthesis convert radiant or solar energy into the  
 a) Physical energy              b) Latent energy              c) Chemical energy              d) Oxidation energy
91. Photolysis of each water molecule in light reaction will yield  
 a) 2 electrons and 4 protons              b) 4 electrons and 4 protons  
 c) 4 electrons and 3 protons              d) 2 electrons and 2 protons
92. Which of the following is the first compound that accepts carbon dioxide during dark phase of photosynthesis?  
 a) NADP                      b) RuBP                      c) Ferredoxin                      d) Cytochrome
93. In a CAM-plant, the concentration of organic acid  
 a) Increases during the day              b) Decreases or increases during the day  
 c) Increases during night              d) Decreases during any time
94. If photosynthesising, green algae are provided with  $CO_2$  labelled with an isotope of oxygen ( $O^{18}$ ), later analysis showed that all of the following compounds produced by the algae contains  $^{18}O$  except  
 a) PGA                      b) RuBP                      c) Glucose                      d)  $O_2$
95. Phytochrome occurs in two forms. In which form it promotes the germination of seeds of some species?  
 a)  $P_{fr}$  form                      b)  $P_r$  form                      c) Both (a) and (b)              d) None of these
96. Solarisation is  
 a) Formation of chlorophyll              b) Destruction of chlorophyll  
 c) Utilization of sunlight              d) Effects of solar light
97.  $C_4$ -pathway is a regular mode of  $CO_2$  fixation in  
 I. dicots  
 II. pteridophytes  
 III. monocots  
 Select the correct option  
 a) I and II                      b) I and III                      c) II and III                      d) I, II and III
98. Carboxylation ( $C_3$ -cycle) is catalysed by  
 a) Carboxylase                      b) RuBP carboxylase              c) RuBP oxygenase              d) Both (b) and (c)



99. The ratio between 2-carbon and 3-carbon intermediates having  $-NH_2$  group formed in photosynthetic oxidation cycle is  
 a) 1 : 1                      b) 2 : 1                      c) 3 : 2                      d) 3 : 4
100. In which one of the following nitrogen is not a constituent?  
 a) Invertase                      b) Pepsin                      c) Idioblast                      d) Bacteriochlorophyll
101. If a chemical process is affected by more than one factors then its rate will be determined by  
 a) Two closely related factors  
 b) Only one factor, which is close to its minimal value  
 c) Only one factor, which is close to its maximum value  
 d) Only one factor, which is close to its appropriate value
102. I. Temperature  
 II.  $CO_2$  concentration  
 III. Chlorophyll arrangement  
 IV. Water  
 Among the given factors, identify the external factors that affects the rate of photosynthesis and correct option accordingly  
 a) I, II and IV                      b) I, II and III                      c) II, III and IV                      d) I, III and IV
103. Which activity is performed by PS-I in light reaction?  
 a) Reduction of NADPH                      b) Reduction of  $NADP^+$   
 c) Oxidation of  $NADP^+$                       d) Oxidation of NAD
104.  $C_4$  pathway for  $CO_2$ -fixation was proposed by  
 a) Benson and associates                      b) Arnon and associates  
 c) Rouhani et al.,                      d) Hatch et al.,
105. A scientist disrupted the chloroplast and separated the stroma from lamella. For fixing  $CO_2$  he supplied stroma with  
 I. ATP  
 II. NADPH  
 III. Glucose  
 Select the correct option  
 a) I and III                      b) III and II                      c) I and II                      d) I, II and III
106. CAM helps the plants in  
 a) Secondary growth                      b) Disease resistance                      c) Reproduction                      d) Conserving water
107. PEP is present in  
 a) Mesophyll cell                      b) Bundle sheath cell                      c) Meristematic cell                      d) Both (a) and (b)
108. The absorption spectrum of chlorophyll  
 a) Showa that some colours of light are absorbed more than the others  
 b) Approximates the action spectrum of photosynthesis  
 c) Explains why chlorophyll is a green pigment  
 d) Has all the above properties
109. PGA as the first carbon dioxide fixation product was discovered in photosynthesis of  
 a) Bryophyte                      b) Gymnosperm                      c) Angiosperm                      d) Alga
110. In  $C_3$ -plants, the first stable compound formed after carbon dioxide fixation is  
 a) Phosphoglyceraldehyde  
 b) Malic acid  
 c) Oxaloacetic acid  
 d) 3-phosphoglycerate
111. Which chemical compound/molecule supplies electrons continuously to PS-II?  
 a)  $CO_2$                       b)  $O_2$                       c)  $H_2O$                       d) NADPH
112. Colour that we see in leaves is due to the presence of  
 I. Chlorophyll-a    II. Chlorophyll-b

III. Xanthophyll IV. Carotenoid

- a) I and II                      b) I, III and IV                      c) II, III and IV                      d) I, II, III and IV
113. Quantasomes occur on the surface of  
a) Cristae                      b) Plasmalemma                      c) Nuclear envelope                      d) Thylakoids
114. First carbon dioxide acceptor in  $C_4$ - plants is  
a) PEP                      b) PGA                      c) RuBP                      d) Pyruvic acid
115. In Calvin cycle, if one molecule of RuBP is carboxylated than how many PGA molecule will be formed?  
a) 2                      b) 3                      c) 4                      d) 5
116. The type of carbon dioxide fixation seen in many succulent plant species is  
a)  $C_4$ -pathway                      b)  $C_2$ -pathway                      c) CAM-pathway                      d)  $C_3$ -pathway
117. Water stress causes the stomata to ...A... hence reducing the ...B... availability.  
Here A and B refer to  
a) A-open; B- $H_2O$                       b) A-close; B- $H_2O$                       c) A-close; B- $CO_2$                       d) A-open; B- $CO_2$
118. Photosynthesis cannot continue for long if during light reaction, only cyclic photophosphorylation takes place. This is because  
a) Only ATP is formed,  $NADPH^+ + H^+$  is not formed                      b) Photosystem-I stops getting excited at a wavelength of light beyond 680 nm  
c) There is unidirectional cyclic movement of the electrons                      d) There is no evolution of oxygen
119. Light reaction of photosynthesis occurs inside  
a) Stroma                      b) Grana  
c) Endoplasmic reticulum                      d) Cytoplasm
120. Bundle sheath cells are rich in which enzyme  
a) PEP carboxylase                      b) Malate dehydrogenase  
c) Phosphofructokinase                      d) RuBisCo
121. In sugarcane plant,  $^{14}CO_2$  is fixed in a malic acid, in which the enzyme that fixes carbon dioxide is  
a) Ribulose phosphate kinase                      b) Fructose phosphatase  
c) Ribulose bisophosphate carboxylase                      d) Phosphoenol Pyruvic acid carboxylase
122. For yielding one molecule of glucose, the Calvin cycle turns  
a) Two times                      b) Four times                      c) Six times                      d) Eight times
123. The light reaction of photosynthesis end up in the formation of  
a)  $NaDH_2$                       b) ATP                      c) Sugar                      d)  $NADPH_2$
124. In leaves of  $C_4$ -plants, malic acid synthesis during carbon dioxide fixation occurs in  
a) Epidermal cells                      b) Mesophyll cells                      c) Bundle sheath cells                      d) Guard cells
125. Biosynthetic phase of photosynthesis is the formation of  
a) Lipid                      b) Fat                      c) Protein                      d) Sugars
126. What happen to the chloroplast pigment when they absorb light?  
a) They become reduced                      b) They become excited  
c) They lose potential energy                      d) Calvin cycle is triggered
127. In  $C_4$ -pathway, the first product identified was  
a) 3-PGA                      b) OAA                      c) 2-PGA                      d) 1-3DPGA
128. Law of limiting factors was given by  
a) Leibig                      b) Blackman                      c) Calvin                      d) Arnon
129. PS-I in cyclic photophosphorylation is involved in the formation of ...A... by ...B... movement of electrons  
What does A and B refer here?  
a) A-ATP; B-down hill redox potential                      b) A-ADP; B-up hill redox potential  
c) A- $NADH + H^+$ ; B-down hill energy                      d) A- $NADPH + H^+$ ; B-down hill energy
130. The green-coloured pigment present in all autotrophs was named chlorophyll by  
a) Pelletier Caventou                      b) Julius Robert Mayer                      c) Jean Senebier                      d) Melvin Calvin
131. Within the chloroplast, there is the membranous system consisting of

- I. grana
- II. stroma lamellae
- III. fluid stroma

Choose the correct option

- a) I and II                      b) II and III                      c) I and III                      d) I, II and III

132. Joseph Priestley observed that when mouse alone was placed in a closed bell jar with burning candle, it was suffocated and candle burning extinguished but when mouse was placed with a mint plant in the same bell jar, that mouse stayed alive and candle continued to burn. What he concluded from this experiment?

- a) Burning candle remove the air                      b) Mint plant restore the air  
c) Both (a) and (b)                      d) CO<sub>2</sub> is required for burning of candle

133. Organelles involved in photorespiration is/are

- I. chloroplast
- II. peroxisomes
- III. mitochondria

Choose the correct option

- a) I and II                      b) II and III                      c) III and I                      d) I, II and III

134. The first step in dark reaction of photosynthesis is

- a) Formation of ATP  
b) Ionization of water  
c) Attachment of carbon dioxide to a pentose sugar  
d) Excitement of electron of chlorophyll by a photon of light

135. Calvin cycle is also called

- a) Calvin-Benson cycle                      b) C<sub>3</sub>-cycle  
c) Reductive pentose pathway                      d) All of the above

136. Plants in which the first product of CO<sub>2</sub> fixation is C<sub>3</sub> acid, *i. e.*, the ...A... pathway, and those in which the first product was C<sub>4</sub> acid (OAA), *i. e.*, the ...B... pathway

Complete the given statement by filling appropriate options in the given blanks

- a) A-C<sub>2</sub>; B-C<sub>3</sub>                      b) A-C<sub>3</sub>; B-C<sub>4</sub>                      c) A-C<sub>4</sub>; B-C<sub>2</sub>                      d) A-C<sub>2</sub>; B-C<sub>3</sub>

137. Photosynthesis is an important process for life on earth because

- a) It is the primary source of all food on earth  
b) It is responsible for the release the of oxygen  
c) It is the only natural process responsible for the utilisation of sunlight  
d) All of the above

138. The mineral involved in the photolysis of water are

- I Manganese                      II Calcium
- III magnesium                      IV Chloride

- a) I and II only                      b) I, II and IV only                      c) I, II and II only                      d) I and IV only

139. Calvin cycle represents

- a) Reductive carboxylation                      b) Substrate level phosphorylation  
c) Dark respiration                      d) Oxidative carboxylation

140. Identify the correct sequence of enzymes given below which participate in the regeneration phase of Calvin cycle.

- I. Ribulose-5-phosphate isomerase
- II. Ribulose-5-phosphate epimerase
- III. Transketolase
- IV. Triose phosphate isomerase

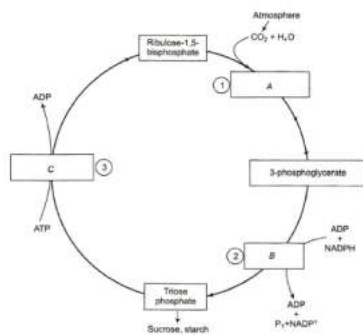
- a) VI, I, III, II                      b) III, IV, II, I                      c) IV, III, I, II                      d) II, I, IV, III

141. Etiolation in plants is caused when they

- a) Are grown in dark                      b) Have mineral deficiency  
c) Are grown in intense light                      d) Are grown in blue light

142. Dichlorophenyl dimethylurea inhibits
- a) PS-I  
b) PS-II  
c) Chloroplast functioning  
d) Oxidative phosphorylation
143. Photosynthetic pigments in chloroplast are embedded in the membrane of
- a) Photoglobulin  
b) Matrix  
c) Thylakoid  
d) Mitochondria
144. Pigments can be separated from leaf by
- a) ELISA test  
b) RIA test  
c) Centrifugation  
d) Paper chromatography
145. In which of the following, oxygen does not evolve during photosynthesis?
- a) Photosynthetic red algae  
b) Photosynthetic green algae  
c) Photosynthetic blue-green algae  
d) Photosynthesis bacteria
146. Who proved that the organic matter is synthesised from carbon dioxide and water during the photosynthesis?
- a) Liebig  
b) Priestley  
c) Ingen Housz  
d) Von Mayer
147. Which of the following statements is true with regard to the light reaction of photosynthesis?
- a) In PS-II the reaction centre chlorophyll- $\alpha$  has an absorption peak at 700 nm hence, is called  $P_{700}$   
b) In PS-I the reaction centre chlorophyll- $\alpha$  has an absorption maxima at 680 nm and is called  $P_{680}$   
c) The spitting of water molecule is associated with PS-I  
d) Photosynthems-I and II are involved in Z scheme
148. In Calvin cycle, the first product identified was
- a) 3-phosphoglyceric acid  
b) 2-phosphoglyceric acid  
c) 1-phosphoglyceric acid  
d) 4-phosphoglyceric acid
149. I. Water is oxidised in PS-I not in PS-II  
II. Light is needed for both PS-I and PS-II  
III. Due to photolysis of water, formation of ATP and NADPH occurs  
IV. Production of NADPH and  $H^+$  is associated with PS-II not PS-I  
Identify the true statement and select the correct option
- a) I and II  
b) II and III  
c) I and IV  
d) II and IV
150. PS-I is located on the
- a) Non-appressed part of a grana thylakoids  
b) Stroma thylakoids  
c) Appressed part of grana thylakoids  
d) Both (a) and (b)
151. I. Chlorophyll-*a*  
II. Chlorophyll-*b*  
III. Anthocyanin  
Select the correct option regarding water soluble pigment
- a) I and II  
b) Only II  
c) Only I  
d) I and II
152.  $C_4$ -plant minimises the photorespiration because  $C_4$ -plants
- a) Use PEPcase to initiate  $CO_2$  fixation  
b) Do not carry out the Calvin cycle in low  $CO_2$  level  
c) Exclude Calvin cycle  
d) Show photorespiration
153. In the process of photosynthesis, water molecule breaks during
- a) Red drop  
b) Photolysis  
c) Phosphorylation  
d) Carbon assimilation
154. Identify A, B and C in the given figure, and choose the correct option from the set (A-C) given below





- a) A-Reduction, B-Carboxylation, C-Regeneration  
 b) A-Reduction, B-Regeneration, C-Carboxylation  
 c) A-Carboxylation, B-Reduction, C-Regeneration  
 d) A-Carboxylation, B-Regeneration, C-Reduction
155. In grana of chloroplast, the reaction  $ADP + P_i = ATP$  during day shows  
 a) Oxidative phosphorylation                      b) Photophosphorylation  
 c) Substrate level phosphorylation              d) Dephosphorylation
156. Very strong light has a direct inhibiting effect on photosynthesis, which is known as  
 a) Solarization                      b) Etiolation                      c) Chlorosis                      d) Defoliation
157. What is the effect of high  $CO_2$  concentration and higher values of ATP/ADP ratio?  
 a) Rate of Calvin cycle increased                      b) Rate of Krebs cycle decreased  
 c) Rate of glycolate cycle decreased                      d) All of the above
158. pH of thylakoid lumen during photosynthesis is  
 a) Basic                      b) Neutral  
 c) Acidic                      d) Depends on  $H^+$  concentration
159. Head portion of the chlorophyll is called ...A... . Tail portion of the chlorophyll is called ...B... . Fill in the with respect to A, B and tick the appropriate option  
 a) A-phytol, B-porphyrin                      b) A-porphyrin, B-phytol  
 c) A-pyrrole ring, B-phytol                      d) A-porphyrin, B-pyrrole ring
160. Members of family-Crassulaceae perform  
 a)  $C_3$ -photosynthesis                      b) CAM-photosynthesis                      c)  $C_4$ -photosynthesis                      d) All of these
161. ...A... plants have the higher temperature optimum than ...B... the plants adapted climate  
 Here A and B refer to  
 a) A-Desert; B-Tropical                      b) A-Temperature; B-Tropical  
 c) A-Tropical; B-Temperature                      d) A-Desert; B-Temperature
162. Which is not correct for ancient plants?  
 a) They have photosynthetic pigment  
 b) They are primitive algae  
 c) They use  $H_2S$  as hydrogen source  
 d) They release oxygen as byproduct
163. Which of the following cell organelles is associated with photorespiration?  
 a) Mitochondria                      b) Peroxisome                      c) Chloroplast                      d) All of these
164. The protons are transported across the thylakoid membrane into the lumen because  
 a) Electrons are transferred to hydrogen carrier is which is present on inner membrane  
 b) Electrons are transferred to electron carrier  
 c) Electrons are transferred to intermembrane space  
 d) Electrons are transferred to hydrogen carrier, which is present outer side of membrane
165. The light phase of photosynthesis is called  
 a) Hill reaction                      b) Photo action  
 c) Pigment action                      d) Chlorophyllous process
166. Which of the following statements are correct?

- I. Light reaction occurs in stroma
- II. Light reaction occurs in grana
- III. Dark reaction occurs in stroma
- IV. Dark reaction occurs in grana

Choose the correct option

- a) I and II
- b) II and IV
- c) III and IV
- d) II and III

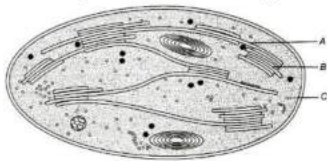
167. In photosynthesis, what does occur in PS-II?

- a) It takes longer wavelength of light and  $e^-$  from  $H_2O$
- b) It takes shorter wavelength of light and  $e^-$  from  $H_2O$
- c) It takes longer wavelength of light and  $e^-$  from NADP
- d) It takes shorter wavelength of light and  $e^-$  from NADP

168. Cyclic-photophosphorylation results in the formation of

- a) NADPH
- b) ATP and NADPH
- c) ATP, NADPH and oxygen
- d) ATP

169. Identify A, B and C in given figure



- a) A-Stroma wall, B-Grana, C-Stroma
- b) A-Stroma lamella, B-Grana, C-Stroma
- c) A-Stroma lamella, B-Stroma, C-Grana
- d) A-Starch grain, B-Stroma, C-Grana

170. In photosystem II, the reaction centre chlorophyll-*a* absorbs ...A... nm wave length of red light causing electron to become excited and jump into an orbit farther from the atomic nucleus. These electrons are picked up by an ...B..., which passes them to an electron transport system consisting of ...C...

Pick the right choice for A, B and C

- a) A-680 nm, B-electron donor, C-cytochromes
- b) A-780 nm, B-electron acceptor, C-cytochromes
- c) A-680 nm, B-electron acceptor, C-cytochromes
- d) A-780 nm, B-electron donor, C-cytochromes

171. Which of the following statements with regard to photosynthesis is/are correct?

- I. In  $C_4$ -plants, the primary  $CO_2$  acceptor is PEP.
- II. In the photosynthetic process, PS-II absorbs energy at or just below 680 nm.
- III. The pigment that is present in the Pigment System-I is  $P_{683}$ .

- a) II and III only
- b) I only
- c) III only
- d) I and II only

172. Which one is correct for  $C_4$ -plants?

**Mesophyll**                      **Bundle Sheath**

- a) PEPcase  $C_4$ -cycle      RuBisCo  $C_3$ -cycle
- b) PEPcase Calvin cycle      RuBisCo  $C_4$ -cycle
- c) RuBisCo  $C_4$ -cycle      PEPcase  $C_3$ -cycle
- d) RuBisCo  $C_2$ -cycle      PEPcase  $C_3$ -cyce

173. Synthesis of food in  $C_4$ -pathway occurs in chlorophyll of

- a) Guard cells
- b) Bundle sheath cells
- c) Spongy mesophyll cells
- d) Palisade cells

174. Which one is the correct reaction of photosynthesis?

- a)  $6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} 6O_2 + C_6H_{12}O_6$
- b)  $6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$
- c)  $C_6H_{12}O_6 + 6O_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} 6CO_2 + 12H_2O + \text{Energy}$
- d)  $C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{Chlorophyll}]{\text{Light}} 6CO_2 + 6H_2O + \text{Energy}$

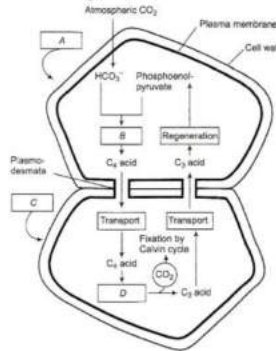
175. I. Lysosome      II. Chloroplast  
III. Peroxisome      IV. Mitochondria

Which of the following organelles is/are not related to photorespiration?

Choose the correct option

- a) Only I                                      b) I, IV and II                                      c) I, III and IV                                      d) Only IV

176. Identify A, B, C and D in the given figure and choose the correct option accordingly



- a) A-Mesophyll cell, B-Fixation, C-Bundle sheath cell, D-Decarboxylation  
 b) A- Mesophyll cell, B-Decarboxylation, C-Bundle sheath cell, D-Fixation  
 c) A-Chloroplast, B-Decarboxylation, C-Bundle sheath cell, D-Fixation  
 d) A-Chloroplast, B-Fixation, C-Bundle sheath cell, D-Fixation

177. In photosynthesis, action and absorption spectrum were related by

- a) Von Helmont                                      b) Englemann                                      c) Emerson                                      d) Lavoisier

178. Which of the following is the formula of chlorophyll-*a*?

- a)  $C_{55}H_{70}O_2N_4Mg$                                       b)  $C_{55}H_{72}O_5N_4Mg$                                       c)  $C_{55}H_{70}O_5N_4Mg$                                       d)  $C_{55}H_{72}O_2N_4Mg$

179. Oxygen which is liberated during photosynthesis, comes from

- a) Carbon cells                                      b) Spongy cells                                      c) Palisade cells                                      d) Bundle sheath cells

180. Photosynthetic organisms remove ..... of carbon/year if assumed that the photosynthetic organisms use 0.1% of incident visible light

- a) 0.1015 tonn                                      b) 0.2015 tonn                                      c) 0.1123 tonn                                      d) 0.03 tonn

181. Light reaction or photochemical phase includes

- I. light absorption  
 II. water splitting  
 III. oxygen release  
 IV. ATP and NADP formation

Select the correct option

- a) I, II and IV                                      b) I, II and III                                      c) I, III and IV                                      d) I, II, III and IV

182. Identify A, B and C shown in a table representing the Calvin cycle

In	Out
A $CO_2$	One glucose
B ATP	ADP
C NADPH	NADP

Choose the correct option

- a) A-5  $CO_2$ , B-18, C-12                                      b) A-6  $CO_2$ , B-12, C-18                                      c) A-4  $CO_2$ , B-12, C-18                                      d) A-6  $CO_2$ , B-18, C-12

183. Rate of photosynthesis is low in herbs, shrubs as compared to sun plants because

- a) Herb, shrubs receive mere red light  
 b) Herb, shrubs receive mere blue light  
 c) Herb, shrubs receive mere more green light  
 d) Herb, shrubs receive more white light

184. PEPcase has an advantage over RuBisCo. The advantage is

- a) RuBisCo combines with  $O_2$  but PEPcase do not  
 b) RuBisCo combines with  $NO_2$  but PEPcase do not  
 c) RuBisCo conserve energy but PEPcase do not  
 d) PEPcase is present in both mesophyll cells and bundle sheath cells but RuBisCo is not



185. Activator of ribulose biphosphate carboxylase oxygenase is  
 a)  $Mg^{2+}$                       b)  $Zn^{2+}$                       c)  $Ca^{2+}$                       d)  $SO_4^{2-}$
186. Photolysis of water during photosynthesis occurs with the help of  
 a) PS-II                      b) PS-I                      c) Ferredoxin                      d) Cytochrome
187.  $RuBP + O_2 \xrightarrow{x} PGA + \text{Phosphoglycolate}$ .  
 Identify  $x$  in the given equation and choose the correct option  
 a) RuBP carboxylase                      b) RuBP oxygenase                      c) RuBisCo                      d) PEP-carboxylase
188. Which one of the following is wrong in relation to photorespiration?  
 a) It is a characteristic of  $C_4$ -plants  
 b) It is a characteristics of  $C_3$ -plants  
 c) It is occurs in chloroplasts  
 d) It occurs in day-time only
189. Flow of electrons in non-cyclic photo phosphorylation is  
 a) Unidirectional (from PS-I to PS-II)                      b) Amphidirectional  
 c) Bidirectional                      d) Unidirectional (from PS-II to PS-I)
190. Priestley discovered oxygen in  
 a) 1770                      b) 1774                      c) 1778                      d) 1782
191. Which of the following is wrongly matched?  
 a) Sorghum – Kranz anatomy                      b) PEP carboxylase – Mesophyll cells  
 c) Blackman – Law of limiting factors                      d) Photosystem-II –  $P_{700}$
192. Transport of  $C_4$  acid from mesophyll cells to the bundle sheath cell takes place through  
 a) Cell membrane                      b) Cell wall                      c) Plasmodesmata                      d) Osmosis
193. Maximum amount of photosynthesis occurs in  
 a) Light compensation point                      b)  $O_2$  compensation point  
 c) Saturation point                      d) Desaturation point
194. Sunken stomata are usually found in  
 a)  $C_3$  plants                      b) CAM plants                      c) Insectivorous plants                      d) Phanerogams
195. I. In  $C_3$ -plant, Calvin pathway takes place in mesophyll cell  
 II. In  $C_4$ -plant, Calvin pathway takes place in the mesophyll cell  
 Which of the following statements true?  
 Choose the correct option  
 a) Statement I is incorrect, II is correct                      b) Statement II is incorrect, I is correct  
 c) Both incorrect                      d) Both correct
196.  $C_3$ -plant show optimum photosynthesis at  
 a) High  $O_2$                       b) High  $CO_2$   
 c) Low  $O_2$                       d) High temperature =  $45^\circ C$
197. During  $C_4$ -cycle, the acid formed are  
 I. Picric acid    II. OAA  
 III. Malic acid    IV. Aspartic acid  
 Select the correct option  
 a) I, II, III and IV                      b) II, III and IV                      c) I, IV and II                      d) I, III and IV
198. Consider the following statements regarding photosynthesis.  
 I. ATP formation during photosynthesis is termed as photophosphorylation.  
 II. Kranz anatomy pertains to leaf.  
 III. Reduction of  $NADP^+$  to  $NADPH$  occurs during Calvin cycle.  
 IV. In a chlorophyll molecule, magnesium is present in phytol tail.  
 a) I and II correct                      b) III and IV are correct  
 c) I and III are correct                      d) I and IV correct
199. Presence of bundle sheath is a characteristic of  
 a) Xerophytic plants                      b) Members of grass family





- c) C<sub>4</sub>-plants  
 200. Oxygenic photosynthesis occurs in  
 a) *Chromatium*                      b) *Oscillatoria*                      c) *Rhodospirillum*                      d) *Chlorobium*
201. I. They have special leaf anatomy  
 II. They tolerate high temperature  
 III. Lack photorespiration  
 IV. Greater productivity of biomass  
 These are the probable characters of  
 a) C<sub>2</sub>-plant                      b) C<sub>3</sub>-plant                      c) C<sub>4</sub>-plant                      d) Any plant
202. In which region, most of the photosynthesis takes place?  
 a) Red and green region                      b) Violet and indigo region  
 c) Blue and red region                      d) Blue and black region
203. In an experiment demonstrating the evolution of oxygen in *Hydrilla*, sodium bicarbonate is added to water in the experimental set-up. What would happen if all other conditions are favorable?  
 a) Amount of oxygen evolved decreases as carbon dioxide in water is absorbed by sodium bicarbonate  
 b) Amount of oxygen evolved increases as the availability of carbon dioxide increases  
 c) Amount of oxygen evolved decreases as the availability of carbon dioxide increases  
 d) Amount of oxygen evolved increases as carbon dioxide in water is absorbed by sodium bicarbonate
204. Who proposed that O<sub>2</sub> comes from water instead from CO<sub>2</sub> during photosynthesis?  
 a) Von Neil                      b) Engelmann                      c) Blackman                      d) Warburg
205. Which equation is correct to prove that O<sub>2</sub> comes from water during photosynthesis?  
 a)  $6\text{CO}_2^{18} + 12\text{H}_2\text{O} \rightarrow 6\text{O}_2^{18} + \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}$   
 b)  $6\text{CO}_2 + 12\text{H}_2\text{O}^{18} \rightarrow 6\text{O}_2 + \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}^{18}$   
 c)  $6\text{CO}_2^{18} + 12\text{H}_2\text{O} \rightarrow 6\text{CO}_2^{18} + \text{C}_6\text{H}_{12}\text{O}_6$   
 d)  $6\text{CO}_2 + 12\text{H}_2\text{O}^{18} \rightarrow 6\text{O}_2^{18} + \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O}$
206. The components of PS-I are located on the  
 a) Stroma                      b) Stroma thylakoid  
 c) Granum thylakoid                      d) Outer surface of stromal and granal thylakoid
207. Cyclic photophosphorylation occurs in  
 a) Stroma lamellae                      b) Appressed part of grana lamellae  
 c) Stroma cell wall                      d) Grana cell wall
208. Identify from the following, a characteristic pigment, which contains copper containing protein  
 a) Plastoquinone                      b) Ferredoxin                      c) Cytochrome                      d) Plastocyanin
209. I. The electrons that carriers photophosphorylation are located in the thylakoid membrane  
 II. During photophosphorylation, the chloroplast stroma becomes more acidic than the interior of thylakoid membrane  
 III. Protons diffuses through the protein channels which are ATP synthetase molecules  
 IV. ATP is formed from ADP + Pi on the stroma side of the thylakoid in the chloroplast  
 V. During photophosphorylation, water ionises to form H<sup>+</sup>, yielding electrons to PS-II  
 Which of the following statement are false?  
 a) I and II                      b) III and IV                      c) IV and V                      d) Only II
210. Which of the following elements is an activator for both Ribulosebiphosphate carboxylase oxygenase and phosphoenol pyruvate carboxylase in photosynthetic carbon fixation?  
 a) Mg<sup>2+</sup>                      b) Zn<sup>2+</sup>                      c) Ca<sup>2+</sup>                      d) SO<sub>4</sub><sup>2-</sup>
211. Who experimentally proved that source of oxygen during photosynthesis is water?  
 a) Van Niel                      b) Robin Hill                      c) Arnon                      d) Emerson
212. Warburg effect is the  
 a) Inhibition of C<sub>4</sub>-cycle by O<sub>2</sub>                      b) Inhibition of C<sub>2</sub>-cycle by O<sub>2</sub>  
 c) Inhibition of C<sub>3</sub>-cycle by O<sub>2</sub>                      d) Inhibition of C<sub>3</sub>-cycle by CO<sub>2</sub>
213. Oxaloacetic acid changes to the malic acid by the action of



- a) Oxaloacetic dehydrogenase  
 c) PEP dehydrogenase
- b) Malic dehydrogenase  
 d) RMP dehydrogenase

214. Consider the following statements.

I. The portion of the spectrum between 300-500 nm is also referred to as Photosynthetically Active Radiation (PAR).

II. Magnesium, calcium and chloride ions play prominent roles in the photolysis of water.

III. In cyclic photophosphorylation, oxygen is not released (as there is no photolysis of water) and NADPH is also not produced.

- a) I is true; but II and III are false  
 c) II is true; but I and III are false
- b) I and II are false; but III is true  
 d) I and II are true; but III is false

215. When two photosystem (I and II) work in a series, the phosphorylation is called

- a) Cyclic  
 b) Non-cyclic  
 c) Bicyclic  
 d) Both (a) and (b)

216. The ATPase enzyme consists of

I.  $F_0$  II.  $F_1$  III.  $F_2$

Select the correct option

- a) I and III  
 b) I and II  
 c) Only I  
 d) II and III

217. Chemiosmosis requires

I. a membrane

II. a proton pump

III. a proton gradient

Select the correct option

- a) II and III  
 b) I and III  
 c) I and II  
 d) I, II and III

218. Biosynthetic phase of photosynthesis is dependent on

I. NADPH II. NADH

III. ATP IV.  $NAD^+ + H^+$

- a) I and III  
 b) IV and I  
 c) I and VI  
 d) IV and II

219. Kranz anatomy is the characteristics of

- a)  $C_5$ -plants  
 b)  $C_3$ -plants  
 c)  $C_2$ -plants  
 d)  $C_4$ -plants

220. In which type of reactions related to plant photosynthesis peroxisomes are involved?

- a) Glycolate cycle  
 b) Calvin cycle  
 c) Bacterial photosynthesis  
 d) Glyoxylate cycle

221. Photosynthesis is a

- a) Catabolic process  
 b) Anabolic process  
 c) Amphibolic process  
 d) Catalytic process

222. Beyond of saturation point, the photosynthesis begins to decline because of

I. Photo inhibition

II. Photo-oxidation

III. Photo-reduction

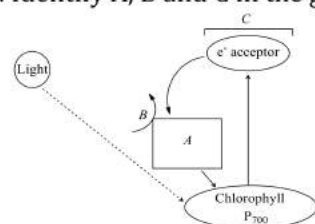
Select the/correct option which matches with statement

- a) I and III  
 b) III and II  
 c) I, II, and III  
 d) I and II

223. A chemical substance when irradiated with UV rays, absorb radiations and emits visible light is called

- a) Luminescent  
 b) Fluorochrome  
 c) Bioluminescence  
 d) Metachrome

224. Identify A, B and C in the given figure of cyclic phosphorylation and choose the correct option accordingly



- a) A-ETS, B- $ADP + Pi \rightarrow ATP$ , C-PS-II  
 c) A- $NADH_2$ , B- $ADP + Pi \rightarrow ATP$ , C-PS-I
- b) A-ETS, B- $ADP + Pi \rightarrow ATP$ , C-PS-I  
 d) A- $NADH_2$ , B- $ADP + Pi \rightarrow ATP$ , C-PS-II

225. Chlorophyll-*a* and *b* differ in having
- a) Chlorophyll-*a* has a methyl group and chlorophyll-*b* has aldehyde group in position X  
 b) Chlorophyll-*a* has an aldehyde group and chlorophyll-*b* has a methyl group in position X  
 c) Chlorophyll-*a* has a carboxyl group and Chlorophyll-*b* has an aldehyde group in position X  
 d) Chlorophyll-*a* has an ethyl group and Chlorophyll-*b* has an aldehyde group in position X
226. Of the total incident solar radiation the proportion of PAR is
- a) About 60%                      b) Less than 50%                      c) More than 80%                      d) About 70%
227. Who discovered that light is essential for releasing oxygen in plants?
- a) Stephen Hales                      b) Lavoisier                      c) Jan Ingenhousz                      d) Von Helmont
228. How many Calvin cycles are required to produce 5 molecules of glucose?
- a) 60                      b) 15                      c) 30                      d) 90
229. During light reaction of photosynthesis
- a) ADP is phosphorylated and NADPH oxidised  
 b) ADP is phosphorylated and NADP reduced  
 c) ADP is phosphorylated and NADPH reduced  
 d) ATP is phosphorylated and NADPH reduced
230. The ATP production in photosynthesis is called
- a) Phototropism                      b) Phosphorylation  
 c) Photooxidation                      d) Photophosphorylation
231. Who described the first action spectrum of photosynthesis?
- a) Sachs                      b) Engelmann                      c) Arnold                      d) Von Helmont
232. Who provided the evidence for the production of glucose when plant grows?
- a) Julius von Sachs                      b) Stephen Hales                      c) Lavoisier                      d) Von Helmont
233. Which of the following is used during discovery of Calvin cycle?
- a) *Spirogyra*                      b) *Volvox*                      c) *Chlamydomonas*                      d) *Chlorella*
234. The movement of electrons in ETC in light reaction is?
- a) Up hill in terms of redox reaction                      b) Down hill in terms of redox reaction  
 c) Either (a) or (b)                      d) Both (a) and (b)
235. The wavelength of light absorbed by  $P_r$  from of phytochrome is
- a) 640 nm                      b) 680 nm                      c) 720 nm                      d) 620 nm
236. In  $C_4$ - plants, the carbon dioxide fixation occurs in
- a) Guard cells                      b) Spongy cells                      c) Palisade cells                      d) Bundle sheath cells
237. What is the name given to the flattened membranous sacs which are embedded in the matrix of the chloroplast?
- a) Thylakoids                      b) Granum                      c) Stroma                      d) Mesophyll cells
238.  $C_4$ -plants are more efficient in photosynthesis than  $C_3$  plants due to
- a) Higher leaf area  
 b) Presence of larger number of chloroplasts in the leaf cells  
 c) Presence of thin cuticle  
 d) Lower rate of photorespiration
239. Which of the following is maximum in chloroplast?
- a) RuBP carboxylase                      b) Hexokinase                      c) Phosphatase                      d) Nuclease
240. Photolysis of water releases
- I. electron  
 II. proton  
 III. oxygen  
 Select the correct option
- a) I and II                      b) II and III                      c) I and III                      d) I, II and III
241. Which of the following characteristics out of I, II, III, IV are exhibited by  $C_4$ -plant?
- I. Kranz anatomy

- II. Oxaloacetic acid  
 III. Large bundle sheath cells  
 IV. Found only in desert area
- a) I, II and III                      b) I, II and IV                      c) II, III and IV                      d) III, I and IV
242. In  $C_4$ -plants, the bundle sheath cells
- a) Have cells density of chloroplast                      b) Are rich in PEPcase  
 c) Have large number of Rubisco                      d) Are large sized having transferase
243. The Z scheme of electron transport is
- a) Cyclic photophosphorylation                      b) Non-cyclic photophosphorylation  
 c) Both (a) and (b)                      d) Where only photosystem pigment-I is involved
244. Photophosphorylation in chloroplast is most similar to the
- a) Mitochondrial substrate level phosphorylation  
 b) Mitochondrial oxidative phosphorylation  
 c) Mitochondrial hydrolysis of  $H_2O$   
 d) All of the above
245. I. Chlorophyll-*a*  
 II. Chlorophyll-*b*  
 III. Xanthophyll  
 IV. Carotenoid
- Separate the given pigments into the accessory and main pigments involved during photosynthesis
- | Main pigment  |             | Accessory Pigment |            |
|---------------|-------------|-------------------|------------|
| a) I          | II, III, IV | b) II, III and IV | I          |
| c) II and III | I and IV    | d) I and IV       | II and III |
246. In photosynthesis, energy from light reaction to dark reaction is transferred in the form of
- a) ADP                      b) ATP                      c) RuBP                      d) chlorophyll
247. RuBisCo performs oxygenase activity at
- a) Low  $CO_2$  concentration                      b) High  $CO_2$  concentration  
 c) High  $H_2O$  concentration                      d) Low  $H_2O$  concentration
248. Primary acceptor of  $CO_2$  in  $C_4$ -cycle is
- a) PGA                      b) PEP                      c) RuBP                      d) OAA
249. In bundle, sheath cells are the large cells around the
- a) Vascular bundles of  $C_4$ -plants                      b) Vascular bundles  $C_3$ -plants  
 c) Vascular bundles of  $C_2$ -plants                      d) All of the above
250. Which of the following is the first compound that accepts carbon dioxide during dark phase of photosynthesis?
- a) NADP                      b) RuBP                      c) Ferredoxin                      d) Cytochrome
251. Number of carboxylation occurs in Calvin cycle is
- a) Zero                      b) One                      c) Two                      d) Three
252. Plants adapted to low light intensity have
- a) Larger photosynthetic unit size than the sun plants  
 b) Higher rate of carbon dioxide fixation than the sun plants  
 c) More extended root system  
 d) Leaves modified to spines
253. If green plants are incubated with  $O^{18}$  labelled water, which molecule (photosynthesis product) will become radioactive from the given options
- a)  $O_2$                       b)  $H_2O$                       c)  $CO_2$                       d) ATP
254. The first action spectrum of photosynthesis was described by Engelman was related to
- a) Algae                      b) Mint plant                      c) Bacteria                      d) Bryophytes
255. To form one molecule of glyceraldehydes phosphate in Calvin cycle
- a) 9 ATP and 36 NADPH are required                      b) 6 ATP and 6 NADPH are required

c) 3 ATP and 3 NADPH are required  
 256. Products of light reaction are ATP and O<sub>2</sub>, of these, B... diffuses out of the chloroplast, while ATP and NADPH are used to derive the process leading to the synthesis of food more accurately, ...C..., What does the blanks A-C refers here?

- a) A-NADP; B-O<sub>2</sub>; C-lipid  
 b) A-NADPH<sub>2</sub>; B-O<sub>2</sub>; C-amino  
 c) A-NAD<sup>+</sup>; B-O<sub>2</sub>; C-sugars  
 d) A-NADPH + H<sup>+</sup>; B-O<sub>2</sub>; C-sugars

257. Light compensation point is the point where  
 a) Gaseous exchange occurs in photosynthesis  
 b) Gaseous exchange do not occur in photosynthesis  
 c) Gaseous exchange reduce in photosynthesis  
 d) Light intensity become appropriate for photosynthesis

258. During the dark reaction, the acceptor of CO<sub>2</sub> is  
 a) NADPH<sub>2</sub>                      b) RuBP                      c) H<sub>2</sub>O                      d) CO<sub>2</sub>

259. During photorespiration, the oxygen consuming reaction(s) occur in  
 a) Stroma of chloroplasts and mitochondria  
 b) Stroma of chloroplasts and peroxisomes  
 c) Grana of chloroplasts and peroxisomes  
 d) Stroma of chloroplasts

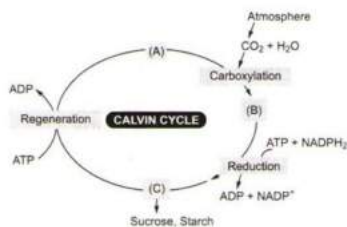
260. Which one of the following concerns Photophosphorylation?

- a)  $ADP + \text{Inorganic PO}_4 \rightarrow \text{ATP}$   
 b)  $AMP + \text{Inorganic PO}_4 \xrightarrow{\text{Light energy}} \text{ATP}$   
 c)  $ADP + AMP \xrightarrow{\text{Light energy}} \text{ATP}$   
 d)  $ADP + \text{Inorganic PO}_4 \xrightarrow{\text{Light energy}} \text{ATP}$

261. In an experiment, chloroplasts were made acidic by soaking them in acidic solution. What will happen if this chloroplast is transferred to a solution having basic pH?

- a) ATP formation takes place  
 b) No ATP formation takes place  
 c) NAD formation takes place  
 d) Sugar formation takes place

262. Choose the correct combination of labeling the carboxydrate molecule involved in the Calvin cycle.



- a) A-RuBP, B-Triose phosphate, C-PGA  
 b) A-PGA, B-RuBP, C-Triose phosphate  
 c) A-PGA, B-Triose phosphate, C-RuBP  
 d) A-RuBP, B-PGA, C-Triose phosphate

263. If the light becomes unavailable during photosynthesis then

- a) Immediately biosynthetic process stops  
 b) Biosynthetic phase does not stops  
 c) Biosynthetic phase stopes forever  
 d) Biosynthetic phase continues for some time and then stops

264. I. In photosynthesis, the proton accumulation is towards the inside of membrane of thylakoid  
 II. In respiration, proton accumulation occurs in the inter membrane space of the mitochondria  
 Select the correct option

- a) Statement I is incorrect II is correct  
 b) Statement II is incorrect I is correct  
 c) Both Statement I and Statement II incorrect  
 d) Both Statement I and Statement II are correct

265. Chloroplasts without grana are known to occur in

- a) Bundle-sheath cells of C<sub>3</sub>-plants  
 b) Mesophyll cells of C<sub>4</sub>-plants

- c) Bundle-sheath cells of  $C_4$ -plants  
d) Mesophyll cells of all plants
266. PGA, the first carbon dioxide fixation product was firstly discovered in  
a) Bryophytes                      b) Pteridophytes                      c) Angiosperms                      d) Alga
267. Liberation of oxygen when green cells in water are exposed to sunlight in presence of suitable acceptor is called  
a) Arnon's reaction                      b) Emerson's enhance effect  
c) Blackman's reaction                      d) Hill's reaction
268. Fixation of one molecule of  $CO_2$  requires how much (in  $C_4$ -plants). ATP and NADPH respectively  
a) 5/2                      b) 2/5                      c) 2/3                      d) 3/2
269. In half leaf experiment, a part of a leaf is enclosed in a test tube containing KOH soaked cotton, while the other half is exposed to air and then setup is placed in light for sometime. It was latter found that part of leaf which was exposed to air tested positive for starch. This indicates that  
a) Light is essential for photosynthesis  
b) Oxygen is liberated in photosynthesis  
c) Water is essential for photosynthesis because in KOH soaked leaf, starch synthesis do not occurs as water reacts with KOH and it become unavailable for photosynthesis  
d) Carbon dioxide is essential for photosynthesis because in KOH soaked leaf, starch synthesis do not occurs as  $CO_2$  is absorbed by, so  $CO_2$  is not available for photosynthesis
270. .... Is a CAM plant.  
a) Maize                      b) Pineapple                      c) Onion                      d) Pea
271. Every  $CO_2$  molecule entering the Calvin cycle needs  
a) 2 molecule of NADPH and 3 molecule of ATP for its fixation  
b) 2 molecule of NADPH and 2 molecule of ATP for its fixation  
c) Variable amount of ATP  
d) Only NADPH
272. Proton gradient is very important across the membrane because  
a) Building up of proton gradient release energy  
b) Building up of proton gradient increase the pH towards lumen side of thylakoid membrane  
c) Breakdown of proton gradient release  $CO_2$   
d) Breakdown of proton gradient release energy
273. The first acceptor of electrons from an excited chlorophyll molecule of Photo system-II is  
a) Cytochrome                      b) Iron-sulphur protein  
c) Ferredoxin                      d) Quinine
274. Substance which is essential for the respiration as well as photosynthesis is  
a) Cytochrome                      b) RuBisCo                      c) Plastocyanin                      d) Ubiquinone
275. Which of the following is a 4-carbon compound?  
a) Oxaloacetic acid                      b) Phosphoglyceric acid  
c) Ribulose biphosphate                      d) Phosphoenol pyruvate
276. A graph that plots the rate at which  $CO_2$  is converted to glucose *versus* the wavelength of light illuminating a leaf is called  
a) An absorption spectrum                      b) An adsorption spectrum  
c) Pigment kinetics                      d) An action spectrum
277. Water stress makes plant leaves ...A... thus, ...B... the surface area of leaves and their metabolic activity as well  
Here A and B refer to  
a) A-wilt, B-increases                      b) A-wilt, B-decreases                      c) A-fall, B-decreases                      d) A-fall, B-increases
278. Which plant performs photosynthesis even after the closing of stomata?  
a)  $C_2$                       b)  $C_3$                       c)  $C_4$                       d)  $C_5$

279. During photorespiration, the conversion of phosphoglycolate to glycolate takes place in this cell organelle.  
 a) Mitochondria                      b) Glyoxysome                      c) Peroxisome                      d) Chloroplast
280. The chemical formula of starch is  
 a)  $(C_6H_{10}O_5)_n$                       b)  $(C_6H_{12}O_6)_n$                       c)  $C_{12}H_{22}O_{11}$                       d)  $CH_3COOH$
281. Emerson effect explain the phenomenon of  
 a) Transpiration                      b) Absorption of water by roots  
 c) Photosynthesis                      d) Respiration
282. Which fractions of the visible spectrum of solar radiations are primarily absorbed by carotenoids of the higher plants?  
 a) Red and violet                      b) Violet and blue                      c) Blue and green                      d) Green and red
283. Photosynthesis in  $C_4$ -plants is relatively less limited by atmospheric carbon dioxide levels because  
 a) Four carbon acids are the initial carbon dioxide acceptors                      b) The primary fixation of carbon dioxide is mediated via PEP carboxylase  
 c) Effective pumping of  $CO_2$  into bundle sheath cells                      d) Rubisco in  $C_4$ - plants has higher affinity for  $CO_2$
284. CAM-plant among the following is  
 a) Maize                      b) *Kalanchoe*                      c) Sugarcane                      d) Wheat
285. Identify the 5-C compound from the given option  
 a) RuBP                      b) OAA                      c) 3PGA                      d)  $NADPH_2$
286. The functions of chloroplast of membrane system is  
 a) Trapping of light energy                      b) Synthesis of ATP  
 c) Synthesis of NADPH                      d) All of these
287. Photophosphorylation differs from oxidative phosphorylation in requiring input of energy in the form of  
 a) Light                      b) Heat                      c) AMP                      d) NAD
288. Cyclic phosphorylation occurs at which wavelength  
 a) Wavelength beyond 800 nm                      b) Wavelength beyond 680 nm  
 c) Wavelength below 680 nm                      d) Wavelength below 500 nm
289. If there is mutation in cytochrome system then this will  
 a) Inhibit the movement of electrons from PS-II to PS-I  
 b) Inhibit the movement of electrons from PS-I to PS-II  
 c) Inhibit the photolysis of water  
 d) Promote ATP formation
290. Photosynthesis is correctly explained by the equation  
 a)  $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$                       b)  $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$   
 c)  $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$                       d)  $2CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 2CO_2$
291. Which of the following elements are essential for the photolysis of water?  
 a) Ca and Cl                      b) Mn and Cl                      c) Zn and I                      d) Cu and Fe
292. The electrons in the reaction centre of PS-I are  
 a) Excited simultaneous with PS-II                      b) Excited simultaneously with  $P_{680}$   
 c) Excited simultaneously with  $P_{700}$                       d) Either (a) or (b)
293. In plants, glycolate metabolism takes place in  
 a) Low concentration of carbon dioxide                      b) High concentration of oxygen  
 c) Low concentration of oxygen                      d) Absence of oxygen
294. Chloroplast align themselves in the mesophyll cell in such away that their flat surface are  
 a) Antiparallel to the cell wall                      b) Perpendicular to the cell wall  
 c) Parallel to the cell wall                      d) Middle in the cell
295. How many molecules of RuBP are required to produce 20 molecules of serine in photorespiration?  
 a) 20                      b) 40                      c) 60                      d) 80
296. With reference to three Calvin cycles, which of the given options is correct for the following question?  
 I. How many gross PGAL molecules are produces?  
 II. Total, how many ATP molecules are required for synthesis of PGAL molecules?



II. Total, how many  $\text{NADPH}_2$  molecules are required for the synthesis of obtained PGAL molecules?

- a) I-3PGAL, II-3 ATP, III-3  $\text{NADPH}_2$
- b) I-6 PGAL, II-6 ATP, III-6  $\text{NADPH}_2$
- c) I-18 PGAL, II-18 ATP, III-18  $\text{NADPH}_2$
- d) I-9 PGAL, II-9 ATP, III-9  $\text{NADPH}_2$

297. Which of the following statements regarding  $\text{C}_4$ -plants is false?

- a) The primary  $\text{CO}_2$  acceptor is a 5-carbon molecule
- b) The initial carboxylation reaction occurs in Mesophyll
- c) The leaves that fix  $\text{CO}_2$  have two cell types
- d) The Mesophyll cells lack Rubisco enzyme

298. CAM pathway is observed in

- a) Pineapple
- b) Maize
- c) Sunflower
- d) Sugarcane

299. Scientist believed that since the first product was ...A... acid, the primary acceptor would be ...B... carbon compound; they spent many years trying to identify a 2-carbon compound before they discovered ...C... carbon compound (RuBP).

Complete the given statement with the correct combination of options

- a) A- $\text{C}_3$ ; B-2, C-5
- b) A- $\text{C}_3$ ; B-5, C-2
- c) A- $\text{C}_4$ ; B-5, C-2
- d) A- $\text{C}_4$ ; B-2, A-5

300. I. Photosystem-I is a photosynthetic pigment system located on the appressed part of grana and thylakoids

II. Photosystem-II is a photosynthesis pigment located on the non-appressed part of stroma only

Identify whether the given statements are correct or incorrect and choose the correct accordingly

- a) Statement I is correct, while II is incorrect
- b) Statement II is correct, while I is incorrect
- c) Both statements are correct
- d) Both statements are incorrect

301. Biosynthetic phase is called as dark reaction because

- a) It depends on the light reaction
- b) It does not depends on the light reaction
- c) It does not depends on  $\text{NADPH}$
- d) It does not depends on  $\text{ATP}$

302. What percentage of solar radiation that hits the earth's atmosphere ever reaches the surface?

- a) 92%
- b) 2%
- c) 42%
- d) 22%

303.  $\text{CO}_2$  released in bundle sheath is used in the

- a)  $\text{C}_4$ -cycle
- b)  $\text{C}_3$ -cycle
- c) Respiration
- d) Sugar break down processes

304. Photophosphorylation is the

- a) Formation of ADP in the presence of light
- b) Formation of ATP in the presence of chemicals
- c) Formation of ATP in the presence of light
- d) Formation of ATP in the presence of reducing agents

305. During photosynthesis,

- a) Oxygen evolved comes from carbon dioxide
- b) ATP is formed
- c) ATP is not formed
- d) Water is required as medium but it does not take part in photosynthesis

306. Cytochrome oxidase is a/an

- a) Exoenzyme
- b) Endoenzyme
- c) Proenzyme
- d) Coenzyme

307. Electrons are transferred by splitting of  $\text{H}_2\text{O}$  through ETC during light reaction and reduces

- a)  $\text{NAD}$  to  $\text{NADH} + \text{H}^+$
- b)  $\text{NADPH}$  to  $\text{H}^+$
- c)  $\text{NADP}^+$  to  $\text{NADPH} + \text{H}^+$
- d)  $\text{NAD}$  to  $\text{NADPH} + \text{H}^+$

308. Cytochrome oxidase contain

- a) Fe
- b) Mg
- c) Zn
- d) Cu

309. Basic features of Kranz anatomy of  $\text{C}_4$ -plant is presence of

- a) Chloroplast in bundle sheath cells
- b) Chloroplast in Mesophyll and epidermal cells
- c) Typical granal chloroplasts in bundle sheath cells and rudimentary chloroplasts in mesophyll cells
- d) Rudimentary chloroplasts in bundle sheath cells and typical granal chloroplasts in mesophyll cells

310. The first product of  $\text{CO}_2$  fixation in  $\text{C}_4$  pathway is





- a) Acetic acid                      b) RuBP                                      c) PGA                                      d) Inorganic acid
311. Photochemical reactions in the chloroplasts are directly involved in  
 a) Fixation of carbon dioxide  
 b) Synthesis of glucose and starch  
 c) Formation of phosphoglyceric acid  
 d) Photolysis of water and phosphorylation of ATP to ATP
312. Which crop utilizes solar energy most efficiently?  
 a) Potato                                      b) Sugarcane                                      c) Wheat                                      d) Rice
313. I. CO<sub>2</sub> is assimilated into sugars  
 II. RUBP is regenerated  
 III. ATP and NADPH are formed  
 Select the correct option in context to Calvin cycle  
 a) I and II                                      b) II and III                                      c) I and III                                      d) I, II and III
314. Majority of energy carrier molecules are oxidised or reduced in the  
 a) Nucleus                                      b) Mitochondria and chloroplast  
 c) Nucleus                                      d) Golgi body
315. The water splitting complex is associated with  
 a) PS-I                                      b) PS-II                                      c) Carotenoid                                      d) Xanthophyll
316. Photosystem I (PS-I) and Photosystem-II (PS-II) are named  
 a) In the sequence they work in light reaction                      b) According to their molecular weight  
 c) In the sequence of their discovery                      d) In the sequence of their constituents
317. Asymmetric labeling of glucose phosphate formed in photosynthesis is called  
 a) Warburg's effect                      b) Pasteur's effect                      c) Gibb's effect                      d) Dicken's effect
318. Protons produced by the splitting of water in light reaction of photosynthesis accumulates within the reaction of photosynthesis accumulates within the  
 a) Lumen of thylakoids                      b) Intermembrane of chloroplast  
 c) Stroma of chloroplast                      d) Outside the lumen of thylakoids
319. The molecule present in the reaction centre of photosystem is  
 a) Chlorophyll-*a*                      b) Chlorophyll-*b*                      c) Chlorophyll-*c*                      d) Chlorophyll-*d*
320. Photorespiration is the light dependent reaction in which utilisation of  
 a) Oxygen and release of H<sub>2</sub>O takes place                      b) Oxygen and release of H<sup>+</sup> takes place  
 c) Oxygen and release of CO<sub>2</sub> takes place                      d) Oxygen and release of ATP takes place
321. Which photosynthetic pigment is called universal photosynthesis pigments?  
 a) Chlorophyll-*a*                      b) Chlorophyll-*b*                      c) Chlorophyll-*c*                      d) Chlorophyll-*d*
322. I. PS-I has more chlorophyll-*a* than chlorophyll-*b*  
 II. PS-II has more chlorophyll-*b* than chlorophyll-*a*  
 Choose the correct option  
 a) I statement is wrong, II is right                      b) II statement is wrong, I is right  
 c) Both statements are wrong                      d) Both statements are right
323. Photosynthesis is a  
 a) Physico-chemical process                      b) Physical process  
 c) Chemical process                      d) Constructive process
324. The C<sub>4</sub>-plants are photosynthetically more efficient than C<sub>3</sub>-plants because  
 a) The carbon dioxide compensation point is more                      b) Carbon dioxide generated during photorespiration is trapped and recycled through PEP carboxylase  
 c) The carbon dioxide efflux is not prevented                      d) They have more chloroplasts
325. We are created by chloroplast. This statement suggest the idea  
 a) All the life form possesses chloroplast  
 b) All the life form depend on photosynthesis

- c) All the life form is plant  
d) Plants are the first organism on earth
326. Which of the following characteristics out of A, B and C are exhibited by  $C_4$ -plants?  
V. Kranz anatomy  
VI. The product of photosynthesis is oxaloacetic acid  
VII. Both PEP carboxylase and ribulose-bisphosphate carboxylase act as carboxylating enzymes.  
a) Only A and B, but not C  
b) Only B and C, but not A  
c) Only A and C, but not B  
d) All A, B and C
327. Hexose monophosphate pathway takes place in  
a) Endoplasmic reticulum  
b) Cristae  
c) Cytoplasm  
d) Mitochondrial matrix
328. The energy required to hydrolyse water during photosynthesis comes from  
a) Reduced chlorophyll  
b) Proton gradient  
c) Oxidised chlorophyll  
d) ATP
329. Chloroplast dimorphism is a characteristic feature of  
a) Plants with Calvin cycle  
b)  $C_4$ -plants  
c) All plants  
d) Only in algae
330. The trapping centre of light energy in photosystem-I is  
a)  $P_{660}$   
b)  $P_{700}$   
c)  $P_{680}$   
d)  $P_{630}$
331. ATP and NADPH produced in light reaction by the movement of electrons in ETC are used immediately for  
a) Oxidation of carbohydrate  
b) Synthesis of sugar  
c) Reduction of carbon dioxide  
d) Both (b) and (c)
332. Electrons which get excited in PS-I must be replaced. These replacements ultimately come from  
a) ATP  
b)  $H_2O$   
c) PS-II  
d) NAD
333. Select the correct pathway for electron transport during photosynthesis  
a)  $CO_2 \rightarrow RUBP \rightarrow Glucose - ATP$   
b)  $H_2O \rightarrow PS-I \rightarrow PS-II \rightarrow NADPH \rightarrow H^+$   
c)  $H_2O \rightarrow PS-II \rightarrow PS-I \rightarrow NADPH \rightarrow H^+$   
d)  $H_2O \rightarrow PS-II \rightarrow PS-I \rightarrow ATP$
334. Photorespiration in  $C_3$ -plants starts from  
a) Phosphoglycerate  
b) Phosphoglycolate  
c) Glycerate  
d) Glycine
335. Photosynthesis is  
I. Endergonic process  
II. Exergonic process  
III. Chemical process  
IV. Physical process  
Select the correct option  
a) II, III and IV  
b) I, III and IV  
c) I, II and IV  
d) I, II and III
336. Compensation point refers to  
a) Little photosynthesis  
b) Beginning of photosynthesis  
c) Rate of photosynthesis equals to the rate of respiration  
d) None of the above
337. In Z-scheme of light reaction the participating pigment systems are  
I. PS-I  
II. PS-II  
III. PS-III  
IV. Carotenoid and xanthophyll  
Choose the correct option  
a) I and II  
b) I, II and III  
c) I, III and IV  
d) II and III and IV
338. Function/s of accessory pigments is/are  
I. They enable wider range of wavelength of incoming light for photosynthesis  
II. They absorb light and transfer the energy to chlorophyll-*a*  
III. They protect reaction centre from photo-oxidation

Select the correct option

- a) I and II                      b) II and III                      c) Only I                      d) I, II and III

339. In CAM-plants, carbon dioxide required for photosynthesis enters the plant body during  
a) Day time through the lenticels  
b) Night through the stomata, which are kept open  
c) Day time when the stomata are open  
d) Night when the hydathodes are open
340. Water is  
a) Produced in dark reaction                      b) A reactant in light reaction  
c) Both (a) and (b)                      d) Involve nowhere in photosynthesis
341. In  $C_3$  plant, when  $O_2$  concentration is more, the  $O_2$  binds to Rubisco and RuBP gets changed to  
a) 2 molecules of PGA  
b) 2 molecules of phosphoglycerate  
c) 2 molecules of phosphoglycolate  
d) One molecule each of phosphoglycerate and phosphoglycolate
342. Within the chloroplast, the chlorophyll pigments are organized in the form of  
a) PS-I                      b) PS-II                      c) PS-III                      d) Both (a) and (b)
343. Conversion of pyruvate into PEP takes place in  
a) Mesophyll cell cytoplasm                      b) Mesophyll cell chloroplast  
c) Bundle sheath cell chloroplast                      d) Bundle sheath cell cytoplasm
344. What is the function performed by plant pigments?  
a) Absorb  $CO_2$                       b) Absorb  $O_2$                       c) Absorb  $H_2O$                       d) Absorb light
345. A reduction in the quantity of oxygen evolution during photosynthesis may be observed at  
a) Light having wavelength more than 680 nm  
b) Light having wavelength less than 680 nm  
c) Light having wavelength 560 nm  
d) Light having wavelength less than 360 nm
346. Organelles associated with photorespiration are  
a) Chloroplast, mitochondria, peroxisome  
b) Chloroplast, mitochondria, lysosome  
c) Mitochondria, peroxisome, centrosome  
d) Nucleus, centrosome, peroxisome
347. Stroma in the chloroplasts of higher plants contain  
a) Light-independent reaction enzymes                      b) Light-dependent reaction enzymes  
c) Ribosomes                      d) Chlorophyll
348. The concentration of  $CO_2$  in atmosphere is between  
a) 0.03-0.04%                      b) 300-400 ppm                      c) 400-600 ppm                      d) Either (a) or (b)
349. Red light favours the ...A... accumulation. Blue light favours the ...B... accumulation  
Here A and B refer to  
a) A-Starch; B-lipid                      b) A-lipid; B-starch  
c) A-carbohydrate; B-cholesterol                      d) A-carbohydrate; B-protein
350. Maximum number of chloroplast are found in  
a) Root                      b) Stem                      c) Leaves                      d) Short tip
351. The net requirement of assimilatory power for the formation of 6 hexose molecules in maize plant is  
a) 72 ATP, 48 NADPH  
b) 90 ATP, 60 NADPH  
c) 108 ATP, 72 NADPH  
d) 180 ATP, 72 NADPH
352. In  $C_3$  plants, the first stable product of photosynthesis during dark reaction is  
a) PGAL                      b) RuBP                      c) PGA                      d) OAA

353. The form of pigment which promotes germination is  
 a) P<sub>760</sub>                      b) P<sub>730</sub>                      c) P<sub>650</sub>                      d) All of these
354. Who proved that oxygen evolved in photosynthesis comes from water?  
 a) Calvin                      b) Mayer  
 c) Blackman                      d) Ruben, Hassid and Kamen
355. Compensation point refers to  
 a) Rate of photosynthesis = Rate of respiration  
 b) Rate of photosynthesis = Rate of H<sub>2</sub>O splitting  
 c) Rate of photosynthesis = PGA formation  
 d) Rate of photosynthesis = RuBP formation
356. Living organisms have the capability of extracting energy from  
 a) Reducible substances                      b) Oxidising substances  
 c) ADP                      d) AMP
357. What happens to C<sub>4</sub> acid in the bundle sheath cells?  
 a) Aspartic acid is deaminated                      b) Malic acid decarboxylated  
 c) Either (a) or (b)                      d) Both (a) and (b)
358. Porphyrin is made up of how many pyrrole ring?  
 a) One                      b) Two                      c) Three                      d) Four
359. In photorespiration, which is light induced cyclic oxidation of photosynthetic intermediates with the help of oxygen, the substrate is  
 a) Glycolate                      b) Glucose                      c) Pyruvic acid                      d) Acetyl Co-A
360. Non-cyclic phosphorylation occurs in  
 I. stroma lamellae  
 II. grana lamellae  
 III. chloroplast membrane  
 Select the correct option  
 a) Only I                      b) II and III                      c) I and III                      d) Only II
361. Sugarcane show high efficiency of carbon dioxide fixation because of  
 a) Calvin cycle                      b) Hatch and Slack cycle                      c) TCA cycle                      d) Greater sunlight
362. Carboxylation (C<sub>3</sub>-cycle) is the fixation of CO<sub>2</sub> into  
 a) Amino acid                      b) Cholesterol ring                      c) Proteins                      d) Organic intermediate
363. Malic acid or aspartic acid and oxaloacetic acid both are found in  
 a) Mesophyll cell                      b) Bundle sheath cell  
 c) Bundle sheath cell wall                      d) Mesophyll cell wall
364. Photorespiration could easily be detected in  
 a) C<sub>3</sub>-plants                      b) C<sub>4</sub>-plants                      c) Both (a) and (b)                      d) None of these
365. Maximum CO<sub>2</sub> fixation is done by  
 a) Green plants                      b) Phytoplanktons                      c) Zooplanktons                      d) Bacteria
366. Grana is ill developed or absent in the chloroplast in the  
 a) Stem of *Hydrilla*                      b) Leaf of sunflower  
 c) Bundle sheath of sugarcane leaf                      d) Mesophyll of grasses
367. Aldolase enzyme is present in  
 a) Mitochondria                      b) Chloroplast  
 c) Lysosomes                      d) Endoplasmic reticulum
368. Photosynthetic enhancement with flashing light was first observed by  
 a) Benson and Calvin                      b) Hill and Calvin  
 c) Hatch and Slack                      d) Emerson and Arnold
369. In C<sub>3</sub> cycle for the fixation of every CO<sub>2</sub> molecules, the reduction and regeneration steps required  
 a) 3 ATP and 2 NADPH<sub>2</sub>                      b) 2 ATP and 2 NADPH<sub>2</sub>                      c) 2 ATP and 3 NADPH<sub>2</sub>                      d) 3 ATP and 3 NADPH<sub>2</sub>
370. Synthesis of one molecule of glucose requires

- a)  $6\text{CO}_2$ , 18 ATP and 12 NADPH  
 b)  $6\text{CO}_2$ , 12 ATP and 18 NADPH  
 c)  $6\text{CO}_2$ , 30 ATP and 12 NADPH  
 d)  $6\text{CO}_2$ , 38 ATP and 12 NADPH

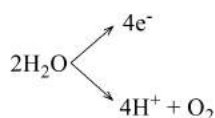
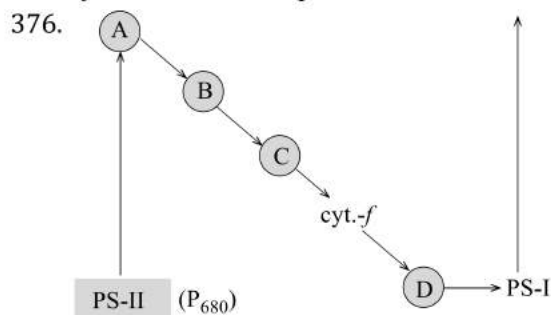
371. Main biosynthetic pathway for  $\text{CO}_2$  fixation in  $\text{C}_4$ -plant is  
 a)  $\text{C}_4$  pathway                      b)  $\text{C}_3$  pathway                      c)  $\text{C}_2$  pathway                      d) Both (a) and (b)

372. I. In biosynthetic phase ( $\text{C}_3$ -cycle), enzymes are present in the matrix of Golgi body  
 II.  $\text{C}_3$  and  $\text{C}_4$ -cycle are two parts of biosynthetic phase of photosynthesis in  $\text{C}_3$ -plants  
 Identify whether the given statements are correct or incorrect and choose the option accordingly  
 a) Both I and II are correct                      b) Both I and II are incorrect  
 c) I is correct, II is incorrect                      d) II is correct, I is incorrect

373. Wavelength of visible light/ PAR is  
 a) 200-400 nm                      b) 700-900 nm                      c) 400-700 nm                      d) 100-200 nm

374. In Hatch and Slack pathway,  
 a) Chloroplasts are of same type  
 b) Kranz anatomy occurs where mesophyll have small chloroplasts whereas bundle sheath have granal chloroplasts  
 c) Kranz anatomy occurs where mesophyll have small chloroplasts whereas bundle sheath have larger agranal chloroplasts  
 d) Kranz anatomy where mesophyll cells are diffused

375. Photorespiration takes place only in  
 a) Lysosomes of plant cell                      b) Green parts of the plant  
 c) Mitochondria of plant cell                      d) None of the above



In the above schematic diagram, which is plastocyanin?

- a) C                      b) D                      c) A                      d) B

377. Photochemical reactions in the chloroplast are directly involved in  
 a) Photolysis of water and formation of ATP                      b) Formation of PGA  
 c) Synthesis of starch and lipid                      d) Fixation of PEP

378. During non-cycle photophosphorylation, in which of the following  $4\text{e}^-$  produced through photolysis will enter?

- a) PS-II                      b) PC                      c) PQ                      d) PS-I

379. Most abundant protein of biological world is

- a) Rubisco                      b) Ligase                      c) Permease                      d) RuBP

380. Core of chlorophyll is formed by

- a) Iron                      b) Manganese                      c) Methyl group                      d) Magnesium

381. Ammonia release from

- a) Photorespiration                      b) Dark respiration                      c) CAM                      d) All of these

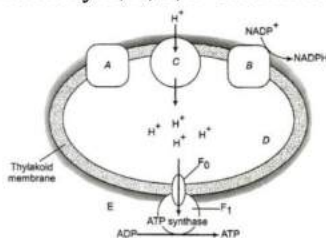
382. Accessory pigments absorb light and transfer it to

- a) Chlorophyll-*b*                      b) Chlorophyll-*a*                      c) Xanthophyll                      d) Carotenoids

383. Formation of ATP in mitochondria is called  
 a) Mitochondria  
 b) Hydrolysis  
 c) Oxidative phosphorylation  
 d) Photophosphorylation
384. Raphides are crystals of  
 a) Calcium carbonate  
 b) Calcium oxalate  
 c) Magnesium carbonate  
 d) Magnesium oxalate
385. Nucleus/core of the chlorophyll contains  
 a) Fe  
 b) Mn  
 c) Mg  
 d) CH<sub>3</sub>
386. (C<sub>5</sub>H<sub>10</sub>O<sub>5</sub>)<sub>n</sub> is the formula of  
 a) Protein  
 b) Fat  
 c) Lipid  
 d) Carbohydrate
387. C<sub>4</sub>- plants differ from C<sub>3</sub>-plants in respect to  
 a) Number of CO<sub>2</sub> molecules used  
 b) Substrate, which accept the CO<sub>2</sub> molecules  
 c) The final product  
 d) Number of ATP formed
388. ATP synthesis is linked to  
 a) Development of pressure gradient across membrane  
 b) Development of osmotic gradient across membrane  
 c) Development of proton gradient across membrane  
 d) Development of electron gradient across membrane
389. Which of the following is formed during photorespiration?  
 a) Sugar  
 b) Phosphoglycolate  
 c) NADPH  
 d) ATP
390. Photosynthesis is maximum in  
 a) Green light  
 b) Blue followed by red light  
 c) Red followed by blue light  
 d) Blue light
391. Large number of chloroplast are present in which of the following cells?  
 a) Parenchymatous cell  
 b) Mesophyll cell  
 c) Peroxisomal cell  
 d) Cell wall
392. What is common between chloroplasts, chromoplasts and leucoplasts?  
 a) Presence of pigments  
 b) Possession of thylakoids and grana  
 c) Storage of starch, proteins and lipids  
 d) Ability to multiply by a fission-like process
393. Which of the following is true for photosynthesis?  
 a) Reduction of CO<sub>2</sub> and water  
 b) Oxidation of CO<sub>2</sub> and water  
 c) Reduction of CO<sub>2</sub> and oxidation of water  
 d) Oxidation of CO<sub>2</sub> and reduction of water
394. RuBisCo is found in  
 a) Cytoplasm  
 b) Nucleus  
 c) Mitochondria  
 d) Chloroplast
395. In C<sub>4</sub>-plants the bundle sheath cells  
 a) Have thin walls to facilitate gaseous exchange  
 b) Have large intercellular spaces  
 c) Are rich in PEP carboxylase  
 d) Have a high density of chloroplasts
396. Find out the reason that creates an important difference between C<sub>3</sub> and C<sub>4</sub>-plant  
 a) Photorespiration  
 b) Calvin cycle  
 c) Glycolysis  
 d) Pressure of cuticle
397. ATPase has  
 a) Channel that allows H<sup>+</sup> diffusion  
 b) Has channel that allows electron diffusion  
 c) Channel that allows diffusion O<sub>2</sub> molecule  
 d) Channel that allows CO<sub>2</sub> molecule
398. In dark reaction, regeneration of RuBP needs  
 a) 2 molecule of ATP  
 b) 1 molecule of ATP  
 c) 3 molecule of ATP  
 d) 4 molecule of ATP

399. Rubisco has the active site that binds to  
 a) CO<sub>2</sub>                                      b) O<sub>2</sub>                                      c) Either (a) or (b)                                      d) NO<sub>2</sub>
400.  $\text{RuBP} + \text{CO}_2 \xrightarrow{\text{Rubisco}} x$ . In the given  
 Identify  $x$  in the given  
 a) 2 × 2 PGA                                      b) 2 × 3 PGA                                      c) 2 × 4 PGA                                      d) 2 × 1 PGA
401. I. Cyclic photophosphorylation needs PS-I and PS-II  
 II. Cyclic photophosphorylation produced NADPH + H<sup>+</sup> and ATP  
 III. Cyclic photophosphorylation involves H<sub>2</sub>O  
 IV. Electrons are recycled in cyclic photophosphorylation  
 Identify the correct and incorrect statement and select the option accordingly  
 a) I, II and III are incorrect, IV is correct                                      b) I, II and IV are incorrect, III is correct  
 c) I, II and III are incorrect, II is correct                                      d) IV, III and I are incorrect, I is correct
402. Which statement about photosynthesis is false?  
 a) The electron carriers involved in photophosphorylation are located on the thylakoid membranes  
 b) Photosynthesis is a redox process, in which water is oxidized and carbon dioxide is reduced  
 c) The enzymes required for carbon fixation are located only in the grana of chloroplasts  
 d) In green plants, both PS-I and PS-II are required for the formation of NADPH + H<sup>+</sup>
403. The C<sub>4</sub>-plants are different from the C<sub>3</sub>-plants with reference to the  
 a) Types of pigments involved in photosynthesis                                      b) The number of NADPH that are consumed in preparing sugar  
 c) Types of end product of photosynthesis                                      d) The substance that accepts carbon dioxide in carbon assimilation and first stable product
404. Identify the incorrect statement with respect to Calvin cycle.  
 a) The carboxylation of RuBP is catalysed by Rubisco                                      b) The first stable intermediate compound formed is phosphoglycerate  
 c) 18 molecules of ATP molecules of ATP are synthesized during carbon fixation                                      d) NADPH + H<sup>+</sup> produced in light reaction is used to reduce diphosphoglycerate
405. NADP reductase enzyme is present on the  
 a) Lumen side of membrane                                      b) Lamellae side of membrane  
 c) Stroma side of membrane                                      d) Cell membrane of chloroplast membrane
406. Cyclic photophosphorylation links to  
 a) PS-II                                      b) PS-I                                      c) Dark reaction                                      d) Both (a) and (b)
407. In photorespiration, what is the role of peroxisome?  
 a) Helps in oxidation of glycolate                                      b) Helps in oxygenation of glycolate  
 c) Helps in synthesis of PGA                                      d) Helps in reduction of glyoxylate
408. Calvin cycle can be described under three stages. These stages are  
 I. carboxylation  
 II. ligation  
 III. reduction  
 IV. regeneration  
 Select the correct option  
 a) II, III and IV                                      b) I, III and IV                                      c) I, II and IV                                      d) I, II and III
409. In which of the following wavelengths, photosystem-I is inactive?  
 a) 780 nm                                      b) 680 nm                                      c) 690 nm                                      d) 550 nm
410. Bacterial photosynthesis involves  
 a) Both PS-I and PS-II                                      b) Either PS-I or PS-II                                      c) PS-I only                                      d) PS-II only
411. The first carbon dioxide acceptor in C<sub>4</sub> cycle is  
 a) RuBP                                      b) PEP                                      c) PGA                                      d) OAA
412. In photo system-I, the first electron acceptor is  
 a) Ferredoxin                                      b) Cytochrome

- c) Plastocyanin  
d) An iron-sulphur protein
413. Fixation of six molecules of  $\text{CO}_2$  needs  
a) 5 turns of Calvin cycle b) 6 turns of Calvin cycle c) 3 turns of Calvin cycle d) 2 turns of Calvin cycle
414. Energy is ...A... to pump protons across a membrane, to create a gradient or high concentration of protons within the thylakoid ...B... ATPase has a channel that allows diffusion of protons back across the membrane. This releases enough energy to activate ...C... enzyme that catalyses the formation of ATP. Complete the given NCERT statement by filling appropriate option in the given blanks  
a) A-released, B-lumen, C-ligase b) A-used, B-lumen, C-ligase  
c) A-used, B-lumen, C-ATPase d) A-released, B-lumen, C-ATPase
415. Photosynthesis and respiration are similar because  
I. in eukaryotes, both processes occur in specialised organelles  
II. ATP synthesis in both is explained by chemiosmotic theory  
III. both use ETC  
Select the correct option  
a) I and II b) II and III c) I and III d) I, II and III
416. Which one does not occur in cyclic photophosphorylation?  
a) Oxygen is not given off b) Water is not consumed  
c) Only photosystem-I is involved d)  $\text{NADPH}_2$  formation
417. Quantum yield of photosynthesis is  
a) 33 % b) 9 % c) 12 % d) 8 %
418. A plant with low carbon dioxide compensation point is  
a) *Atriplex patula* b) *Leucopoa kingii*  
c) *Gossypium hirsutum* d) *Tidestromia oblongifolia*
419. Select the wrongly matched pair with regard to  $\text{C}_4$  cycle.  
a) Primary  $\text{CO}_2$  fixation-PGA product  
b) Site of initial-Mesophyll cells carboxylation  
c) Primary  $\text{CO}_2$  acceptor-PEP  
d)  $\text{C}_4$  plant-Maize
420. ATP synthesised by cells in  
I. chloroplast II. Mitochondria  
III. Golgi body  
Select the correct option  
a) I and III b) I and II c) II and III d) I, II and III
421. In which cells of leaf, pyruvate is converted to PEP in  $\text{C}_4$  pathway?  
a) Epidermal cells b) Mesophyll cells  
c) Bundle sheath cells d) Guard cells
422. Identify A, B, C, D and E from the given figure and choose the correct option accordingly



- a) A-PS-I, B-PS-II, C-cytochrome-*b* and *c*, D-Lumen stroma, E-Stroma  
b) A-PS-I, B-PS-II, C-cytochrome-*b* and *c*, D- Stroma, E- Lumen  
c) A-PS-II, B-PS-I, C-cytochrome-*b* and *c*, D-Stroma, E- Lumen  
d) A-PS-II, B-PS-I, C-cytochrome-*b* and *c*, D- Lumen, E-Stroma
423. 3-PGA is first stable product in  
a) Carbon-reduction cycle b) Photorespiration



c) Light reaction

d) All of these



## PHOTOSYNTHESIS IN HIGHER PLANTS

### : ANSWER KEY :

1)	d	2)	d	3)	d	4)	c	165)	a	166)	d	167)	b	168)	d
5)	d	6)	d	7)	c	8)	a	169)	b	170)	a	171)	d	172)	a
9)	b	10)	d	11)	a	12)	c	173)	b	174)	b	175)	a	176)	a
13)	a	14)	b	15)	b	16)	b	177)	b	178)	b	179)	b	180)	a
17)	c	18)	a	19)	d	20)	a	181)	d	182)	d	183)	c	184)	a
21)	c	22)	d	23)	a	24)	d	185)	a	186)	a	187)	b	188)	a
25)	a	26)	b	27)	b	28)	b	189)	d	190)	b	191)	d	192)	c
29)	b	30)	d	31)	a	32)	a	193)	c	194)	b	195)	b	196)	b
33)	b	34)	a	35)	d	36)	b	197)	b	198)	a	199)	c	200)	b
37)	d	38)	c	39)	d	40)	d	201)	c	202)	c	203)	b	204)	a
41)	c	42)	c	43)	a	44)	b	205)	d	206)	d	207)	a	208)	d
45)	a	46)	c	47)	a	48)	b	209)	d	210)	c	211)	b	212)	c
49)	a	50)	b	51)	a	52)	a	213)	b	214)	b	215)	b	216)	b
53)	b	54)	c	55)	c	56)	c	217)	d	218)	a	219)	d	220)	a
57)	c	58)	c	59)	b	60)	c	221)	b	222)	c	223)	b	224)	b
61)	a	62)	d	63)	c	64)	d	225)	a	226)	b	227)	c	228)	c
65)	d	66)	d	67)	b	68)	a	229)	b	230)	d	231)	b	232)	a
69)	c	70)	d	71)	a	72)	c	233)	d	234)	b	235)	b	236)	d
73)	b	74)	a	75)	a	76)	d	237)	a	238)	b	239)	a	240)	c
77)	a	78)	c	79)	a	80)	b	241)	a	242)	c	243)	b	244)	b
81)	b	82)	d	83)	c	84)	d	245)	a	246)	b	247)	a	248)	b
85)	c	86)	a	87)	c	88)	a	249)	a	250)	b	251)	b	252)	a
89)	d	90)	c	91)	b	92)	b	253)	a	254)	a	255)	d	256)	d
93)	c	94)	d	95)	a	96)	b	257)	b	258)	b	259)	b	260)	d
97)	b	98)	b	99)	b	100)	c	261)	a	262)	d	263)	d	264)	d
101)	b	102)	a	103)	b	104)	d	265)	c	266)	d	267)	d	268)	a
105)	c	106)	d	107)	a	108)	d	269)	d	270)	b	271)	a	272)	d
109)	d	110)	d	111)	c	112)	d	273)	d	274)	a	275)	a	276)	a
113)	d	114)	a	115)	a	116)	c	277)	b	278)	c	279)	d	280)	a
117)	c	118)	a	119)	b	120)	d	281)	c	282)	b	283)	b	284)	b
121)	d	122)	c	123)	d	124)	b	285)	a	286)	d	287)	a	288)	b
125)	d	126)	b	127)	b	128)	b	289)	a	290)	a	291)	b	292)	d
129)	d	130)	b	131)	a	132)	c	293)	a	294)	c	295)	b	296)	d
133)	d	134)	c	135)	d	136)	b	297)	a	298)	a	299)	a	300)	d
137)	c	138)	d	139)	a	140)	c	301)	a	302)	c	303)	b	304)	c
141)	a	142)	b	143)	c	144)	d	305)	b	306)	b	307)	c	308)	a
145)	d	146)	a	147)	d	148)	a	309)	d	310)	a	311)	d	312)	b
149)	b	150)	d	151)	b	152)	a	313)	a	314)	b	315)	b	316)	c
153)	b	154)	c	155)	b	156)	a	317)	c	318)	a	319)	a	320)	c
157)	d	158)	c	159)	b	160)	b	321)	a	322)	b	323)	a	324)	d
161)	c	162)	d	163)	d	164)	a	325)	b	326)	c	327)	c	328)	c



329) b	330) b	331) d	332) b	381) a	382) b	383) c	384) b
333) c	334) b	335) b	336) c	385) c	386) d	387) b	388) c
337) a	338) d	339) b	340) c	389) b	390) c	391) b	392) d
341) d	342) d	343) b	344) d	393) c	394) d	395) d	396) a
345) a	346) a	347) a	348) d	397) a	398) b	399) c	400) b
349) d	350) c	351) d	352) c	401) a	402) c	403) d	404) c
353) c	354) d	355) a	356) b	405) c	406) b	407) a	408) b
357) c	358) d	359) a	360) d	409) a	410) c	411) b	412) d
361) b	362) d	363) a	364) a	413) b	414) c	415) b	416) d
365) b	366) c	367) b	368) d	417) c	418) d	419) a	420) b
369) a	370) a	371) b	372) d	421) b	422) d	423) a	
373) c	374) c	375) b	376) b				
377) a	378) a	379) a	380) d				



# PHOTOSYNTHESIS IN HIGHER PLANTS

## : HINTS AND SOLUTIONS :

- 1 **(d)**  
12 extra ATP molecules are needed for production of one molecule of one molecule of hexose sugar in  $C_4$ -plant.
- 2 **(d)**  
Movement of protons across the membrane to stroma.  
Proton gradient is important because it is the break down of this gradient that leads to release of energy. The gradient is broken down due to movement of protons across the membrane to the stroma through the transmembrane channel of the  $F_0$  of the ATPase.  
The energy released during the breaking down of proton gradient is used in formation of ATP
- 3 **(d)**  
Chemical equation for photosynthesis can be shown as  
$$CO_2 + 2H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light energy (hv)}} (CH_2O)_n + H_2O + O_2 \uparrow$$
  
or 
$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{(hv)} C_6H_{12}O_6 + 6H_2O + 6O_2 \uparrow$$
  
Glucose
- 4 **(c)**  
Thylakoid membrane
- 5 **(d)**  
RuBP carboxylase/ oxygenase (RUBISCO) is an enzyme present in the stroma of chloroplast. This enzyme is responsible for primary carboxylation in  $C_3$ -plants as a 5C sugar RuBP acts as carbon dioxide acceptor in the presence of this enzyme and produces 6C unstable compound which then splits into two molecules of 3-phosphoglyceric acid (3C compound), the first stable product of  $C_3$ -cycle.
- 6 **(d)**  
Law of limiting factor was proposed by **F F Blackman** (1905). It stated that 'when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of the slowest factor' (*i.e.*, factor present minimum amount).
- 7 **(c)**  
Assimilation and reduction of carbon dioxide takes place during Calvin cycle. This cycle takes in only one carbon (as  $CO_2$ ) at a time so it takes six turns to produce a hexose or glucose molecule (6 carbon). In Calvin cycle, for formation of one mole of hexose sugar (glucose) 18 ATP and 12  $NADPH_2$  are used. The assimilatory power ( $NADPH_2$  and ATP) are generated in light reaction of photosynthesis.
- 8 **(a)**  
In stroma, enzymatic reactions incorporate  $CO_2$  into the plant leading to the synthesis of sugar, which in turn forms the starch
- 9 **(b)**  
The process of photosynthesis in  $C_4$ -plants and CAM (crassulacean Acid Metabolism) is same. But instead of spatial separation of initial PEP case fixation and final RUBISCO fixation of carbon dioxide, the two steps occurs in the same cells but at different times, night and day, *e.g.*, *Opuntia*, pineapple, *Vanilla*. PEP (Phosphoenol Pyruvic Acid) is the first acceptor of carbon dioxide in CAM-plants like  $C_4$ -plants.
- 10 **(d)**  
PEP carboxylase or pepco is the special enzyme, which is found in the mesophyll cells of  $C_4$ -plant. Pepco is capable of fixing  $CO_2$  more efficiently in  $C_4$ -plant than Rubisco, even in low  $CO_2$  concentration
- 11 **(a)**  
Law of limiting factor was proposed by **Blackman** in 1905. He started that when a process is conditional as to its rapidity by a number of separate factors, then the rate of the process is determined by the pace of slowest factor. Carbon dioxide is usually a limiting factor in



- photosynthesis under field conditions particularly on clear summer days under adequate water supply.
- 12 (c) PS or Photosystem is made of a reaction centre and an antenna molecule
- 13 (a) Chloroplasts are the green plastids which take part in photosynthesis and temporary or permanent storage of starch. These are discoid (disc-shaped) in higher plants with diameter of 4-6  $\mu\text{m}$  and thickness of 2-4  $\mu\text{m}$ .
- 14 (b) RuBPFirals one  $\text{CO}_2$  molecule in  $\text{C}_3$  plants with the help of enzyme Rubisco.
- 15 (b) Cyclic photophosphorylation involves only photo system-I and a few electron carriers. During cyclic photophosphorylation, ATP is formed but NADPH does not formed.
- 16 (b) Photosynthesis involves the conversion of light energy to chemical energy by photosynthetic pigments using water and carbon dioxide and producing carbohydrate.
- 17 (c) **Plastoquinone** transfer electron from photo system-II to photo system-I. Electrons released from  $\text{P}_{700}$  or photo system-I moves through Fe-S, plastoquinone, cytochrome and plastocyanin and are recycled to  $\text{P}_{700}$ . In this process, only ATP is produced but no oxygen produced.
- 19 (d) The fact that  $\text{C}_3$ -plants respond to higher  $\text{CO}_2$  concentration by showing increased rates of photosynthesis leading to higher productivity has been used for some greenhouse crops such as tomatoes and bell pepper. They are allowed to grow in carbon dioxide enriched atmosphere that leads to higher yields
- 20 (a) Copper is component or activator of ptastocyanin, cytochrome oxidase, RuBP carboxylase and many other enzymes. It has major role in electron transfer, maintenance of carbohydrate, nitrogen balance and chlorophyll synthesis.
- 21 (c) The two pigment system theory of photosynthesis was proposed by **Emerson** *et. al.*
- 22 (d) In photosystem-I, the photocentre is a special chlorophyll-a molecule called  $\text{P}_{700}$ , which is active in both red and far-red light, while a very small amount of special form of chlorophyll-a called  $\text{P}_{680}$ , constitutes the reaction centre of photo system-II. PS-II is inactive in far-red light (beyond 680 nm).
- 23 (a) Chlorophyll-*a*
- 24 (d) The rate of photosynthesis is very important in determining the yield of plants including crop plants. Photosynthesis is under the influence of several factors, both internal (plant) and external. The plant factors includes the number, size, age and orientation of leaves, mesophyll cells and chloroplast, internal  $\text{CO}_2$  concentration and the amount of chlorophyll. The plant or internal factors are dependent on the genetic predisposition and the growth of the plant
- 25 (a) In the experiment for starch synthesis in green leaves, two leaves, a variegated leaf or a leaf that was partially covered with black paper and other one that was exposed to light were taken. On testing these leaves for starch, it was clear, that photosynthesis had occurred only in the green parts of the leaves in the presence of light
- 26 (b) The process of photorespiration was firstly discovered in tobacco plant. It is the light dependent day time process of oxygenation of RuBP. It takes place in the chloroplast and characteristic of  $\text{C}_3$ -plants
- 27 (b) Photosynthesis is manufacture of organic compounds inside the chlorophyll containing cells from  $\text{CO}_2$  and water with the help of sunlight. Photosynthetic unit occur in the form of two distinct groups called pigment systems. The first reaction in photosynthesis is excitation of chlorophyll molecule.
- 28 (b)  **$\text{C}_4$ -plants** show Kranz anatomy. In Kranz anatomy, bundle sheath cells are arranged radially around the vascular bundles, which look like a ring or wreath. The chloroplasts in  $\text{C}_4$ -leaves are dimorphic.
- 29 (b)

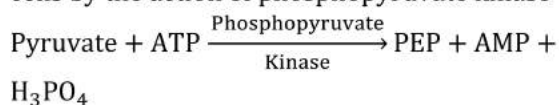
- Conversion of carbon dioxide to simple (reduced) organic compounds is called carbon dioxide fixation or carbon dioxide assimilation or carbon fixation. This fixation pathway was elucidated by **Melvin Calvin** and is often called as Calvin cycle.
- 30 **(d)**  
**Hill reaction** was discovered by **Robert Hill** in 1939. It involves the release of oxygen from isolated illuminated chloroplasts when suitable electrons acceptors (*e.g.*, **potassium ferricyanide**) are added to the surrounding water.
- 31 **(a)**  
 In mesophyll cells the PEP carboxylase is present and RuBisCo is absent.  
 In bundle sheath cells the RuBisCo is present and PEP carboxylase is absent
- 32 **(a)**  
 Due to the punctured thylakoid membrane, the interior of thylakoid is no longer separated from stroma that leads to the disturbed proton gradient.  
 The proton concentration between the thylakoid membrane and stroma becomes the same. Hence, no ATP formation takes place as ATP formation takes place due to the proton gradient
- 33 **(b)**  
 Because only respiration is taking place at this intensity of light.
- 34 **(a)**  
 During the cyclic phosphorylation, the electrons does not pass to the  $\text{NADP}^+$  but cycled back to PS-I through electron transport chain. This cyclic flow hence, results only in the synthesis of ATP but no of  $\text{NADPH} + \text{H}^+$ . Cyclic photophosphorylation occurs when only light of wavelength beyond 700 nm is available for excitation
- 35 **(d)**  
 Calvin cycle occurs in the stroma not grana.  
 During the Calvin cycle, synthesis of starch takes place  
 Photosynthetic reaction in purple sulphur bacteria
- $$2\text{H}_2\text{S} + \text{CO}_2 \xrightarrow{\text{Light}} 2\text{S} + \text{CH}_2\text{O} + \text{H}_2\text{O}$$
- Absence of light leads to the stoppage of splitting of water which causes stoppage of photosynthesis
- 36 **(b)**  
 Carbon dioxide is usually a limiting factor in photosynthesis under normal conditions
- particularly, clear summer days under adequate water supply
- 37 **(d)**  
 Cytochromes are iron containing pigments. These act as electron transporter or electron acceptor in respiration and photosynthesis both.
- 38 **(c)**  
 The light harvesting complex is made up of hundreds of pigment molecules bounded to proteins
- 39 **(d)**  
 Molecular formula of chlorophyll-*a* and *b* are as follow:  
 $\text{C}_{55}\text{H}_{72}\text{O}_5\text{N}_4\text{Mg}$ -Chlorophyll-*a*  
 $\text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$ -Chlorophyll-*b*
- 40 **(d)**  
 In the leaves of  $\text{C}_4$ -plants, the vascular bundles are surrounded by bundle sheath of larger parenchymatous cells, which in turn are surrounded by mesophyll cells. Bundle sheath cells have a high density of larger chloroplasts which always lack grana, whereas chloroplasts of mesophyll cells are smaller.
- 41 **(c)**  
 Steps in chemosynthetic ATP synthesis are  
 (i) Light excites electron in PS-II  
 (ii) Electrons from PS-II pass along electron to move  $\text{H}^+$  across the membranes  
 (iii) Carriers use energy from electrons to move  $\text{H}^+$  across the membrane  
 (iv)  $\text{H}^+$  concentration gradients is established  
 (v)  $\text{H}^+$  diffuses through ATP synthesis  
 (vi) Energy of  $\text{H}^+$  flow is used by ATP synthesis to make ATP
- 42 **(c)**  
 Visible light consists of radiation having a wavelength between 390-760 nm (or 3900-7600 Å). It can be resolved into light of different colours. Namely, violet (390-430 nm), blue (430-470 nm) blue-green (470-500 nm), green (500-580 nm), yellow (580-600 nm), orange (600-650 nm), red (650-660 nm), red (660-760 nm)  
 Red light above 760 nm is called infrared and the light radiation shorter than the violet is called ultraviolet light
- 43 **(a)**  
 The site for photorespiration is chloroplast. Peroxisome and mitochondria are required for completing the process. This happen at high temperature and high oxygen concentration.

- 44 **(b)**  
Genetic predisposition.  
The rate of photosynthesis is very important in determining the yield of plants including crop plants. Photosynthesis is under the influence of several factors, both internal (plant) and external. The plant factors includes the number, size, age and orientation of leaves, mesophyll cells and chloroplast, internal CO<sub>2</sub> concentration and the amount of chlorophyll. The plant or internal factors are dependent on the genetic predisposition and the growth of the plant
- 45 **(a)**  
Each water molecule on photolysis yields one H<sup>+</sup> and OH<sup>-</sup> ion  
 $H_2O \rightarrow 2H^+ + [O] + 2e^-$   
So, by 12H<sub>2</sub>O molecule in photolysis 24 H<sup>+</sup> will product
- 46 **(c)**  
In non-cyclic photophosphorylation, evolutions of oxygen take place. It becomes possible due to photolysis of water molecules into H<sup>+</sup> and OH<sup>-</sup> ions. Later on OH<sup>-</sup> ion reassociate and form water and oxygen, while H<sup>+</sup> ions go to NADP<sup>+</sup> (a hydrogen acceptor).  
Each water molecule on photolysis yields one H<sup>+</sup> and OH<sup>-</sup> ion  
 $H_2O \rightleftharpoons HO^- + H^+$   
 $2OH + 2OH \rightleftharpoons 2H_2O + O_2 \uparrow$   
So, 12 H<sub>2</sub>O  $\rightleftharpoons$  12OH<sup>-</sup> + 12H<sup>+</sup>
- 47 **(a)**  
Red light
- 48 **(b)**  
The Calvin cycle is common between the C<sub>3</sub> and C<sub>4</sub>-cycle. In C<sub>4</sub>, it takes place in bundle sheath and in C<sub>4</sub>, it takes place in mesophyll cells
- 49 **(a)**  
Chlorophyll is the principle pigment involved in photosynthesis. Chlorophyll-*a* is the major pigment involved in trapping light energy and converting it into electrical and chemical energy. Chlorophyll-*b* molecules also act as accessory pigment. Other accessory pigments are phycoerythrin, phycocyanin, carotenoids, etc. the accessory pigment and reaction centre together from photo system.
- 50 **(b)**  
In photosynthesis, carbon dioxide is reduced and water is oxidised.
- 51 **(a)**  
C<sub>4</sub>-plants have Kranz anatomy, which includes bundle sheath cells and mesophyll cells. In case of C<sub>4</sub> plants, the primary CO<sub>2</sub> acceptor is a 3-carbon molecule. *i.e.*, phosphoenol pyruvate and is present in the mesophyll cells
- 52 **(a)**  
Chloroplast, which is a cytoplasmic cell organelle, is found only in eukaryotic plant cells. These structures help in the manufacture of food through photosynthesis. Chlorophyll is a specialized light absorbing pigment, which is found in the inner wall of granum. Each granum is a flat, sac-like structure, in which light reaction of photosynthesis takes place.
- 53 **(b)**  
ATP is synthesised by cells (in mitochondria and chloroplast) and the process is named as phosphorylation. Photophosphorylation is the synthesis of ATP from ADP and inorganic phosphate in the presence of light. When the two photosystems work in a series, first PS-II and then the PS-I, a process called non-cyclic photophosphorylation occurs. The two photosystem are connected through an electron transport chain, as seen earlier- in the Z scheme. Both ATP and NADPH + H<sup>+</sup> are synthesised by this kind of electron flow. When only PS-I is functional, the electron is circulated within the photosystem and the phosphorylation occurs due to the cyclic flow of electrons
- 54 **(c)**  
As per Peter Mitchell's Chemiosmotic coupling hypothesis, outward pumping of protons across the inner chloroplast or mitochondrial membrane results in accumulation of protons between outer membrane and inner membrane. A proton gradient is thus established. As protons now flow back passively down the gradient, the proton motive force is utilised to synthesis ATP.
- 55 **(c)**  
**Action Spectrum** is the curve depicting the relative rate of photosynthesis at different wave-length of light. It shows that the maximum photosynthesis occur at the blue red region. These regions are the absorption region of chlorophyll-*a*. So, the action spectrum of photosynthesis is almost identical to the absorption spectrum of chlorophyll-*a*
- 56 **(c)**  
Loss of all leaves would do maximum harm to a tree. Due to this, the rate of photosynthesis will

decreased, which results in the decrease of metabolic activities.

57 (c)

Regeneration of PEP takes place in mesophyll cells by the action of phosphopyruvate kinase



58 (c)

Loss of energy occurs during **photorespiration**. Photorespiration is light induced oxidation of photosynthetic intermediates with the help of oxygen and release of carbon dioxide. Energy is not released during photorespiration.

59 (b)

Two molecules of glycine condense to form a molecule of serine and carbon dioxide and ammonia are released.

60 (c)

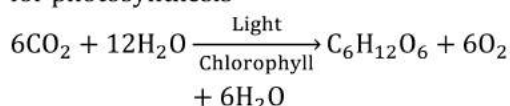
C<sub>4</sub> Plants have Rubisco-enzyme. In C<sub>3</sub> plants Carboxylation of RuBP leads to formation of PGA.

61 (a)

Photorespiration is the light dependent process of oxygenation of ribulosebiphosphate (RuBP) and release of carbon dioxide by the photosynthetic organs of a plant. More oxygen and less carbon dioxide is helpful in photorespiration.

62 (d)

H<sub>2</sub>O, CO<sub>2</sub>, light, chlorophyll are the raw material for photosynthesis



63 (c)

In C<sub>4</sub>-plants, characteristics Kranz anatomy is found. Vascular bundles are surrounded by two rings of cells-

1. Bundle sheath cell contains starch rich chloroplast, lacking grana.
2. Mesophyll cell, which does not distinguished into palisade and spongy parenchyma.

64 (d)

Starch.

Julius von Sachs provided evidence for the production of glucose when plants grow. Glucose is usually stored as starch. His later studies showed that the green substance in plants (chlorophyll as we know it now) is located in

special bodies (later called chloroplast) within plant cells.

He found that the green parts in plants are where glucose is made, and that the glucose is usually stored as starch

65 (d)

Photosynthesis is a process, in which green plants manufacture their own food with help of carbon dioxide and water in presence of sunlight and takes place in chloroplast. In the question, no photosynthesis takes place because the chloroplast is not intact.

66 (d)

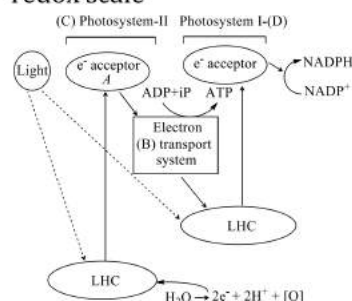
The value of carbon dioxide compensation point is 25-100 ppm in C<sub>3</sub>-plants and less than 5 ppm in C<sub>4</sub>-plants. Thus, compensation point of C<sub>3</sub>-plants is higher than C<sub>4</sub>-plants.

67 (b)

During downhill movement, the electrons releases energy, which converted ADP into ATP.

68 (a)

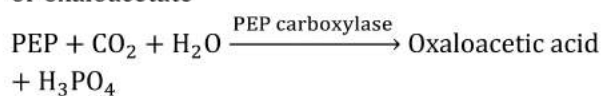
Transport of electrons in photosynthesis takes place from the PS-II to PS-I through electrons transport system. In the electron transport system, there are various cytochrome, which carries electrons to the down hill potential of redox scale



69 (c)

PEP carboxylase.

In C<sub>4</sub>-plants the initial fixation of carbon dioxide occurs in mesophyll cell. The primary acceptor of CO<sub>2</sub> is phosphoenol pyruvate or PEP. It combines with carbon dioxide in presence of PEP carboxylase or PEPcase to form oxaloacetic acid or oxaloacetate



70 (d)

Stroma lamellae lacks both PS-II and NADP reductase due to the occurrence of cyclic photophosphorylation

71 (a)



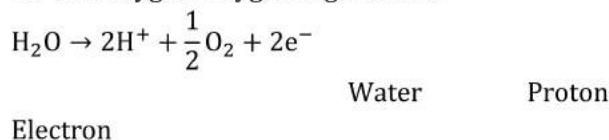
- Rubisco** stands for ribulosebisophosphate carboxylase oxygenase. Ribulose 1, 5-biphosphate (RuBP) is carbon dioxide acceptor in  $C_3$ -plants.
- 72 (c) The thylakoids of chloroplast are flattened vesicles arranged as a membranous network within the stroma. 50% chloroplast proteins and various components involved (namely chlorophyll, carotenoids and plastoquinone) are present in thylakoids membranes that are involved in photosynthesis.
- 73 (b) DUMC (Dichlorophenyl Dimethyl Urea) is a herbicide, which inhibits oxygen evolution and non-cyclic Photophosphorylation. Oxygen evolution and non-cyclic Photophosphorylation, both are involve in PS-II.
- 74 (a) In CAM-plants, malic acid is formed during night without Kranz anatomy.
- 75 (a) Energy formed on the stroma side thylakoids membrane during light reaction, *i.e.*,  $NADPH + H^+$  of ATP, is used by the Calvin cycle or dark reaction to form the starch or carbohydrates
- 76 (d) Plants that are adapted to dry tropical regions generally have the  $C_4$  pathway. Though these plants have the  $C_4$ -oxaloacetic acid as the first  $CO_2$  fixation product they use the  $C_3$  pathway or the Calvin cycle as the main biosynthetic pathway
- 77 (a) Maximum photosynthesis rate has been observed in the full spectrum. Regarding the effect of different wavelengths, maximum photosynthesis occurs in red light (660 nm), second maximum in blue (440 nm) and minimum in green
- 78 (c) During the light reaction, the splitting of water gives two proton, one oxygen and two electrons. Protons are used in the formation of protein gradient across the thylakoid membrane. Oxygen is liberated as byproduct. Electrons goes to the PS-II and to the electron transport chain
- 79 (a) **Adenosine diphosphate** (ADP) contains one high energy bond. The second phosphate bond of ADP can release 7300 calorie of free energy per mol on hydrolysis. Adenosine triphosphate (ATP) has two high energy bonds.
- 80 (b) At places, the thylakoids are aggregated to form stacks of discs called grana. A granum may have 20-50 thylakoid discs. The thylakoids lying outside the grana are called stroma thylakoids or intergranal thylakoids (lamellae)
- 81 (b) The chemiosmotic hypothesis explains the ATP synthesis mechanism. Like in respiration, in photosynthesis too, ATP synthesis is linked to the development of proton gradient across the membrane. This time these are the membranes of the thylakoid. There is one difference that in photosynthesis the proton accumulation is towards the inside of membrane, *i.e.*, in the lumen. In respiration, proton accumulate in the intermembrane of the mitochondria when electrons move through the ETS (Electron Transport System)
- 82 (d) Glucose molecule contains-6 carbon. For fixing one carbon ( $CO_2$ ). Calvin cycle needs 3 ATP and 2 NADPH. Then for fixing six carbon ( $C_6H_{12}O_6$ ), Calvin cycle needs 18 ATP and 12 NADPH. The net reaction of  $C_3$  dark fixation of  $CO_2$  is  $6 RuBP + 6 CO_2 + 18 ATP + 12 NADPH$
- 83 (c) Five types of chlorophyll are present in plants namely *a, b, c, d, e* out of these, only two chlorophyll, *i.e.* ; *a* and *b* occurs in all chloroplast of higher plants. Thus, they are called the main plant photosynthesis pigments
- 84 (d)  $C^{14}$  is an isotope of carbon. It has been used to draw the path of carbon fixation in the process of photosynthesis. This labelled  $C^{14}$  becomes incorporated with  $^{14}CO_2$ , which is accepted by RuBP and 3 carbon compounds, phosphoglyceric acid (3-PGA) is formed. 3-PGA is the first stable compound.
- 85 (c) Anthocyanin is a water soluble pigment. It constitute a class of natural phenolic product. These provide colour to petals and fruits.
- 86 (a) **Robert Emerson** discovered Pigment System-I (PS-I) and Pigment System-II (PS-II).
- 87 (c) Photorespiration is also called the glycolate or oxidative photosynthetic carbon cycle

88 (a) **M D Hatch** and **C R Slack** found that in certain plants growing in tropical climates, the first product of photosynthesis is a  $C_4$ -compound instead of a  $C_3$ -compound. These plants are now known as  $C_4$  - plants or **Hatch and Slack type plants**. The  $C_4$ -plants show Kranz type anatomy, e.g., sugarcane, Corn, *Euphorbia*, etc.

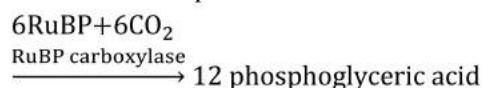
89 (d) Both PS-I and PS-II are involved in non-cyclic photophosphorylation.

90 (c) Photosynthesis converts radiant energy or the solar energy into chemical energy. Some energy gets stored in the organic food between different atoms. Photosynthetic products provide energy to all organisms to carry out their life activities

91 (b) The phenomenon of breaking up of water into hydrogen and oxygen in the illuminated chloroplasts is called photolysis. Light energy, an oxygen evolving complex and an electron carrier  $Y_z$  are required. Electron carrier  $Y_z$  transfer the released electrons to  $P_{680}$ . The oxidised  $P_{680}$  regains its electrons by the photolysis of water into  $2H^+$ ,  $2e^-$  and oxygen. Oxygen is given out.



92 (b) Dark phase of photosynthesis of Calvin cycle takes place in the stroma of chloroplast. First step of dark phase is Carboxylation. In Carboxylation, carbon dioxide is combined with RuBP to form first stable compound.



93 (c) In CAM-plants, carbon dioxide enters into the leaf and fixed to oxaloacetic acid, which is then converted to malic acid at night when stomata are open. This malic acid is stored in cells during night. So, in CAM-plants, organic acids accumulate (or their concentration increases) in the dark (i.e., at night) in vacuoles.

94 (d) Oxygen evolved by the splitting of  $H_2O$   
 $2H_2O \rightarrow 4H^+ + 4e^- + O_2$

So, the isotopic oxygen ( $O^{18}$ ) molecule in  $CO_2$  will be incorporated into the PGA, RuBP, glucose. Isotopic  $O^{18}$  is not found in oxygen liberation

95 (a)  $P_{fr}$  From, induces the seed germination.

96 (b) Photosynthesis starts at quite low intensity of light but very high intensity cause solarisation, i.e., disintegration of chlorophyll molecules. Solarisation may reduce the photosynthetic activity.

97 (b)  $C_4$  pathway is seen in angiosperms (dicot and monocots). It is absent in the lower forms of plants, like Pteridophyta or Bryophyta or algae

98 (b) RuBP carboxylase oxygenase

99 (b) During photorespiration in Peroxisome, two molecules of glycine ( $2H_2NCH_2 - CO_2$ ) are transferred into mitochondrion, where they are converted into one molecule of serine ( $HOCH_2 - H_2NCH - CO_2$ ). Thus, the ratio between 2C and 3C intermediates having  $-NH_2$  group is 2:1.

100 (c) **Idioblast** seems to be the most appropriate choice. Invertase and pepsin are enzyme proteins (contain nitrogen) and bacteriochlorophyll also contains nitrogen. Idioblasts are cells having crystals of calcium oxalate, called raphides.

101 (b) Only one factor, which is close to the minimal value. Law of limiting factor was proposed by F. F. Blackman. (1905). It stated that when a process is conditioned as to its rate by number of separate factors, the rate of the process is limited by the pace of the slowest factor (i.e., the factor present in minimum amount)

102 (a) The external factors would include the availability of sunlight, temperature,  $CO_2$  concentration and water. As a plant photosynthesises, all these factors will simultaneously affect its rate. Hence, through several factors interact and simultaneously affect photosynthesis or  $CO_2$  fixation, usually one factor is the major cause or is the one that limits the rate. Hence, at any point the rate will be determined by the factor available at sub-optimal levels

- 103 **(b)**  
Reduce  $\text{NADP}^+$ .  
Light reaction begins with the PS-II. In photosystem-II the reaction centre chlorophyll-*a* absorb 680 nm. wavelength of red light causing electrons to become excited and jump into orbit further from the nucleus. These electrons are picked up by an electron acceptor, which passes them to an electron system consisting of cytochromes.  
The movement of electrons in ETS of photosynthesis is down hill in terms of oxidation reduction or redox potential scale. The electrons are not used up as they pass through the electron transport chain, but they passed on the pigments of photosystem I. Simultaneously, electrons in the reaction centre of PS-I are also excited, when they receive red light of wavelength 700 nm and are transferred to another acceptor molecule that has greater redox potential. These electrons than are moved down hill again this time to a molecule of energy rich  $\text{NADP}^+$ . The addition of these electrons reduces the  $\text{NADP}^+$  to  $\text{NADPH} + \text{H}^+$
- 104 **(d)**  
The detailed study of  $\text{C}_4$ -cycle was introduced by **M D Hatch** and **C R Slack** (1966).
- 105 **(c)**  
In stroma, the fixing of  $\text{CO}_2$  takes place by expanding  $\text{NADPH}_2$  and ATP formed by light reaction. So, scientist should have supplied  $\text{NADPH}_2$  and ATP to intact stroma for  $\text{CO}_2$  fixation
- 106 **(d)**  
CAM plants are mostly succulent xerophytes. The stomata in these plants remain closed during the day. They help to check the transpiration. In this way, water is conserved.
- 107 **(a)**  
PEP (Phosphoenol pyruvate) present in mesophyll cell
- 108 **(d)**  
Absorption spectrum of chlorophyll explain the green colour of chlorophyll. It is approximate to action spectrum of photosynthesis and the rate is different at different colour.
- 109 **(d)**  
The use of radioactive  $^{14}\text{C}$  by Melvin Calvin in algal (*Chlorella*) photosynthesis studies led to the discovery that the first carbon dioxide fixation product was a 3-carbon organic acid. The first product identified was 3-phosphoglyceric acid (PGA).
- 110 **(d)**  
The first step or Calvin Cycle or  $\text{C}_3$ -pathway is Carboxylation in which a 5 C sugar RuBP acts as carbon dioxide acceptor in the presence of enzyme RUBISCO and produces 6C unstable compound. This unstable 6C compound splits into molecules of 3-phosphoglyceric acid (3C-compound), which is the first stable product of this pathway.
- 111 **(c)**  
 $\text{H}_2\text{O}$ .  
Electron excited by PS-I used in the formation of  $\text{NADPH} + \text{H}^+$ . These electrons come ultimately from  $\text{H}_2\text{O}$  through photosynthesis
- 112 **(d)**  
A chromatographic separation of the leaf pigment shows that the colour that we see in leaves is not due to the single pigment but due to four pigments. They are Chlorophyll-*a* (bright or blue green in chromatogram), Chlorophyll-*b* (yellow green), Xanthophyll (yellow) Carotenoids (yellow to yellow orange)
- 113 **(d)**  
Quantasomes are present on inner membrane of thylakoids. Each quantasome have 230 molecules of chlorophyll.
- 114 **(a)**  
In  $\text{C}_4$ -plants, leaf shows Kranz anatomy. In these plants, the carbon dioxide first accepted in the mesophyll cells by PEP (phosphoenol pyruvate) and form a four carbon compound oxaloacetic acid.
- 115 **(a)**  
Carboxylation of one molecule of RuBP leads to the formation of 2 molecules of PGA  

$$\text{RuBP} + \text{CO}_2 \xrightarrow[\text{carboxylase}]{\text{RuBP}} 2 \text{ -carboxyl 3-keto 1-5, bisphosphoribotol.}$$

$$2\text{-carboxyl 3-Keto 1-5-bisphosphoribotol} + \text{H}_2\text{O} \rightarrow 2\text{PGA}$$
- 116 **(c)**  
CAM-pathway (Crassulacean Acid Metabolism) is a mechanism of photosynthesis involving double fixation of carbon dioxide, which occurs in succulents belonging to Crassulaceae, cacti, euphorbias and some other plants of dry habitats

- where the stomata remain closed during the daytime and open only at night.
- 117 (c) A-Close, B-CO<sub>2</sub>. Water stress causes the stomata to close hence, reducing the CO<sub>2</sub> availability
- 118 (a) Assimilatory power, i.e., ATP and NADPH<sub>2</sub> should produced during light reaction of photosynthesis.
- 119 (b) Grana are the stacks of thylakoids which contain photosynthetic pigments. Therefore, grana are the sites of light reaction.
- 120 (d) In bundle sheath cell C<sub>3</sub>-cycle performed. So, these cells have high number of RuBisCo as compared to other cells
- 121 (d) In C<sub>4</sub>-plants, carbon dioxide is picked up by phosphoenol pyruvate (PEP) and the reaction being catalysed by **PEP carboxylase**.
- 122 (c) Conversion of carbon dioxide to simple (reduced) organic compounds is called carbon dioxide assimilation or carbon dioxide fixation or carbon fixation. This fixation pathway was elucidated in the early 1950s by **Melvin Calvin** and coworkers and is often called as Calvin cycle. Since, one molecule of carbon is fixed in one turn of the Calvin cycle. So, **six** turns of the cycle are required to fix the glucose molecule containing six carbon atoms.
- 123 (d) The light reaction of photosynthesis ends up in the formation of NADPH<sub>2</sub> from NADP<sup>+</sup>
- 124 (b) In C<sub>4</sub>-plants, the Hatch and Slack pathway involves two carboxylation reaction, one taking place in chloroplast of mesophyll cells and other in chloroplast of bundle sheath cells.
- 125 (d) Synthesis of sugars or carbohydrates is called the biosynthetic phase of photosynthesis. This process does not directly depends on the presence of light but is dependent on the products of the light reaction, i.e., ATP and NADPH, besides CO<sub>2</sub> and H<sub>2</sub>O. This could be verified immediately after light becomes unavailable. The biosynthetic process continues for sometime and then stops. If then, light is made available, the synthesis starts again
- 126 (b) Light reaction begins with the PS-II. In photosystem-II the reaction centre chlorophyll-*a* absorb 680 nm. wavelength of red light causing electrons to become excited and jump into orbit further from the nucleus. These electrons are picked up by an electron acceptor, which passes them to an electron system consisting of cytochromes
- 127 (b) CO<sub>2</sub> assimilation during photosynthesis generally takes place in two ways in plants  
(i) **C<sub>3</sub> pathway** Those plants in which the first product of CO<sub>2</sub> fixation is a C<sub>3</sub> acid (PGA), i.e., the C<sub>3</sub> pathway  
(ii) **C<sub>4</sub> pathway** Those plants in which the first product C<sub>4</sub> acid (OAA), i.e., the C<sub>4</sub> pathway
- 128 (b) **Blackman** (1905) extended the law of minimum to formulate the law of limiting factors, which in his own words is 'when a process is conditioned as to its rapidity by a number of separate factors, the rate of the process is limited by the pace of slowest factor.'
- 129 (d) Only PS-I is involved in cyclic photophosphorylation the formation of ATP when the electrons move down hill in term of redox potential
- 130 (b) **Julius Robert Mayer** gave name chlorophyll to green pigment present in autotrophs.
- 131 (a) Within the chloroplast, there is the membranous system (grana, stroma lamellae) and fluid it is called stroma
- 132 (c) Joseph Priestley observed that a candle burning in a closed, a bell jar, soon gets extinguished. Similarly, a mouse would soon suffocate in a closed space. He conclude that a burning candle or an animal that breathe the air, both somehow, damage the air. But when he placed a mint plant in the same bell jar, he found that the mouse stayed alive and the candle continued to burn. Priestly hypothesised that plants restore to the air whatever breathing animals and burning candles remove
- 133 (d)

In photorespiration, the three subcellular compartments namely, the chloroplast, peroxisomes and mitochondria are involved

134 (c)

The first step in dark reaction of photosynthesis is Carboxylation, in which six molecules of carbon dioxide combine with six molecules of ribulose 1, 5-biphosphate (RuBP) to form six molecules of unstable six carbon compound. Carboxylation of RuBP is catalysed by the enzyme RuBP carboxylase or **RUBISCO**.

135 (d)

The other names for Calvin cycle are Calvin Benson Cycle,  $C_3$ -cycle, and reductive pentose phosphate pathway

136 (b)

$CO_2$  assimilation during photosynthesis generally takes place in two ways in plants

(i)  **$C_3$  pathway** Those plants in which the first product of  $CO_2$  fixation is a  $C_3$  acid (PGA), *i.e.*, the  $C_3$  pathway

(ii)  **$C_4$  pathway** Those plants in which the first product  $C_4$  acid (OAA), *i.e.*, the  $C_4$  pathway

137 (c)

Ultimately, all living forms on the earth depends on sunlight for energy. The use of energy from sunlight by the plants for doing photosynthesis is the basis of life on earth. Photosynthesis is important due to two reasons. It is the primary source of food on earth and it is responsible for the release of oxygen into the atmosphere by green plants

138 (d)

Photolysis of water involves the splitting of water molecules into  $OH^-$  and  $H^+$  ions in the presence of light. This phenomenon is associated with pigment system-II and is catalysed by the presence of  $Mn^{2+}$  and  $Cl^-$  ions.

139 (a)

Calvin cycle or dark reaction is the reductive carboxylation leading to the formation of sugar. That's way, it is also called the reductive pentose pathway

140 (c)

Triose phosphate isomerase enzyme converts glyceraldehydes-3 phosphate molecule into dihydroxy acetone phosphate. Then an enzyme **transketolase** comes, which acts on sedoheptulose-7-phosphate molecule and changes it into ribulose-5-

phosphate and xylulose-5-phosphate. Then ribulose-5-phosphate isomerase enzyme comes and acts on ribulose-5-phosphate. This reaction has a molecule of ribulose-5-phosphate, while xylulose-5-phosphate molecule is also converted into ribulose-5-phosphate by another enzyme, ribulose-5-phosphate epimerase.

141 (a)

Etiolation involves the destruction of chloroplasts and, hence all the chlorophyll when the plants are grown in dark.

142 (b)

DCMU (Dichlorophenyl dimethylurea) is a herbicide, which inhibits oxygen evolution and non-cyclic photophosphorylation. Oxygen evolution and non-cyclic photophosphorylation, both are involved in PS-II

143 (c)

Pigments are embedded in thylakoids. According to **Emerson**, there are two systems, PS-I lies on outer surface and PS-II in inner surface of thylakoids.

144 (d)

The Russian botanist Mikhail Tswett is credited with the original development of a separation technique that we now recognise as a form of chromatography. In 1903, he reported the successful separation of plant pigments by using a column of calcium carbonate

145 (d)

Like green plants, some purple and green sulphur bacteria are capable of synthesising their organic food in presence of light, which is known as **bacterial photosynthesis**.

146 (a)

In 1845, Liebig proved that organic matter synthesised during photosynthesis is derived from carbon dioxide and water

147 (d)

Photophosphorylation is the synthesis of ATP from ADP and inorganic phosphate in the presence of sun-light. When the two photosystems work in series, first PS-II and then the PS-I, a process called non-cyclic Photophosphorylation occurs. The two photosystems are connected through an electron transport chain in the Z-scheme (due to the shape of path of electrons flow). Both ATP and  $NADH+H^+$  are synthesized by this kind of electron flow.

148 (a)

Melvin Calvin used radioactive  $^{14}\text{C}$  in algal photosynthesis, which led to the discovery that the first  $\text{CO}_2$  fixation product was a 3-carbon organic acid. He also contributed to working out the complete biosynthetic pathway; hence it was called **Calvin cycle** after him.

The first product identified was **3-phosphoglyceric acid** or **PGA**. For this, he was awarded Nobel Prize

149 (b)

Water is oxidised by PS-II, the reaction is  $2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{O}_2 + 4e^-$

These electrons goes to the PS-I one by one through ETS (Electron Transport System) on reaching to the PS-I. They reduces  $\text{NADP}^+$  to  $\text{NADPH} + \text{H}^+$

150 (d)

PS-I is present on both the non-appressed part of grana thylakoids as well as on stroma thylakoids

151 (b)

Anthocyanin is water soluble pigment. It constitutes a class of natural phenolic product. These provide colour to petals and fruit. Chlorophyll-*a* and *b* are water insoluble pigments. They are soluble in organic solvents

152 (a)

$\text{C}_4$ -plants have very little photorespiration because its initial carbon fixation is done by PEP carboxylase not by Rubisco. Beside this,  $\text{C}_4$ -plant generate their own  $\text{CO}_2$  by decarboxylation of  $\text{C}_4$  acids in bundle sheath. Due to these reasons, the  $\text{C}_4$ -plants minimise photorespiration

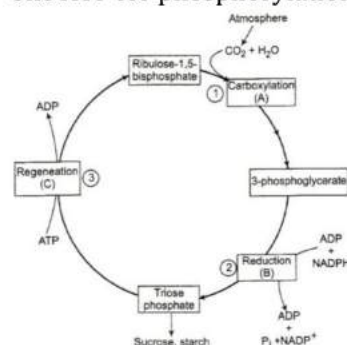
153 (b)

Photolysis is the phenomenon of breaking up of water into hydrogen and oxygen in the illuminated chloroplasts. It is also called, photocatalytic splitting of water. It requires light energy, an oxygen evolving complex and an electron carrier. It also requires the ions,  $\text{Cl}^-$ ,  $\text{Mn}^{2+}$

154 (c)

**The Calvin cycle proceeds in three stages** (1) carboxylation, during which  $\text{CO}_2$  combines with ribulose 1, 5-bisphosphate; (2) reduction, during which carbohydrates are formed at the expense of the photochemically made ATP and NADPH; and (3) regeneration during,  $\text{CO}_2$  acceptor is ribulose 1, 5-bisphosphate is formed again so that the cycle continues. Regeneration of the  $\text{CO}_2$  acceptor

molecule, RuBP is crucial if the cycle is to continue uninterrupted. The regeneration steps require one ATP for phosphorylation to form RuBP



155 (b)

During Photophosphorylation, ATP is formed.

156 (a)

Usually with increase in light intensity the rate of photosynthesis increased. At very high light intensity the cells exhibit photooxidation by the process of solarization and if continues for few hours, the photosynthetic apparatus is destroyed.

157 (d)

Due to the higher value of  $\text{CO}_2$  and ATP, the rate of Calvin cycle increases to form carbohydrate (starch). This leads to inhibition of photorespiration (glycolate cycle) and Krebs's cycle

158 (c)

During the photosynthesis within chloroplast protons in the stroma decreases in number, while in lumen there is accumulation on protons. This create a proton gradient across the thylakoid membrane as well as a measurable decrease in pH (acidic) in the lumen

159 (b)

Chlorophyll structure was studied by Wilstatler, Stoll and Fisher in 1912. It has a tadpole like structure with head called porphyrin and a tail made up of long chain alcohol called phytol. Porphyrin head is made up of four pyrrole rings, which are linked by methane a bridges ( $-\text{CH} =$ )

160 (b)

Members of family-Crassulaceae perform CAM photosynthesis.

161 (c)

A-Tropical, B-Temperate. Tropical plants have a higher temperature optimum than the plants adopted to temperate climate

162 (d)

Ancient plants were like cyanobacteria. These plants used hydrogen source other than water and, therefore, did not release oxygen from photolysis of water.

163 (d)

Photorespiration ( $C_2$  cycle) is a special type of respiration shown by many green plants ( $C_3$  plants) when they are exposed to light. It is a light dependent process during which oxygen is used and carbon dioxide is released. The process of photorespiration takes place only in chlorophyllous tissues of plants. Therefore, the main site for photorespiration is chloroplast. But mitochondria and peroxisomes are also required to complete the process.

164 (a)

Electrons are transferred to hydrogen carrier, which is located towards the outer side of the membrane

165 (a)

**Hill reaction** also called light reaction is a photochemical reaction. In this, reduced enzymes and phosphate bond energy (ATP) are produced.

166 (d)

In chloroplast, the light reaction occurs in grana and dark reaction in stroma

167 (b)

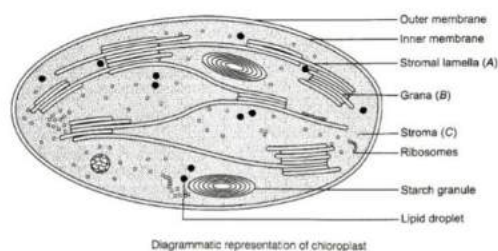
PS-II absorbs maximum 680 nm wavelength of light, thus reaction centre is  $P_{680}$ . PS-II extracts an electron from water, returning to its unexcited state because hydrolysis of water occurs in PS-II. Oxygen evolved in PS-II comes from water.

168 (d)

Cyclic-photophosphorylation involves only pigment system-I. When the photons activate PS-I, a pair of electrons are raised to higher energy level. They are captured by primary acceptor, which passes them on to ferredoxin, plastoquinone, cytochrome complex, plastocyanin and finally back to reaction centre of PS-I, *i.e.*,  $P_{700}$ . At each step of electron transfer, the electrons lose potential energy. Their trip down hill is caused by the transport chain to pump  $H^+$  across the thylakoids membrane. The proton gradient thus established is responsible for forming ATP (2 molecules). But no reduction of NADP to  $NADPH + H^+$  takes place.

169 (b)

A-Stroma lamella, B-Grana, C-Stroma



170 (a)

A-680 nm, B-electron donor, C-cytochromes

171 (d)

$C_4$ -plants show Kranz anatomy. In these plants, the primary carbon dioxide acceptor in mesophyll cells is phosphoenol pyruvate (PEP).

In light reaction of photosynthesis, PS-II absorbs energy at or just below 680 nm, while PS-I absorbs energy at 700 nm.

172 (a)

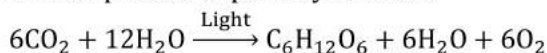
In  $C_4$ -plants, the PEP case is present in mesophyll cells ( $C_4$ -cycle) and RuBisCo is present bundle sheath cells ( $C_3$ -cycle)

173 (b)

$C_4$ -pathway occurs in some tropical plants having Kranz anatomy (undifferentiated mesophyll around vascular bundles with chloroplast containing bundle sheath). The final  $CO_2$  fixation occurs in bundle sheath cells.

174 (b)

The correct equation that would represent the overall process of photosynthesis is

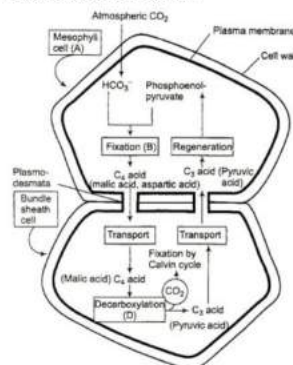


175 (a)

The site for photorespiration is chloroplast. Peroxisomes and mitochondria are required for completing the process. This happens at high temperature and high oxygen concentration. Lysosome are not involved in photorespiration

176 (a)

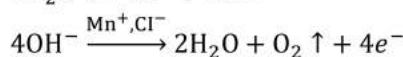
In the Hatch and Slack pathway ( $C_4$ -cycle), the first stable compound is  $C_4$  organic acid called oxaloacetic acid



177 (b) **Englemann** studied the effect of different region of the visible spectrum on the rate of photosynthesis of different algae. The amount of oxygen release was found to be maximum in blue and red absorption bands of chlorophyll.

178 (b) The empirical formula of chlorophyll-a is  $C_{55}H_{72}O_5N_4Mg$ .

179 (b) Oxygen, which is liberated during photosynthesis comes from water.



180 (a) It is estimated that photosynthetic organism remove  $100 \times 1015$  grams (.1015 + tonn) of carbon/year (Houghton and Wood well 1990)

181 (d) Light reaction starts when solar radiation or light falls on the PS-II. Light reaction is also called photochemical phase, which includes light absorption, water splitting, oxygen release and formation of high energy chemical inter mediates like ATP and NADPH

182 (d)

In	Out
Six $CO_2$	One glucose
18 ATP	18 ADP
12 NADPH	12 NADP

183 (c) Minimum photosynthesis occur in the green wavelength. Plants grow under the canopy like herbs and shrubs receive very little red and blue-violet light because of its absorption by leaves of the canopy. They receive more of green light that is transmitted through leaves. As a result, the photosynthesis in herbs and shrubs is comparatively low

184 (a) PEPcase has an advantage over the RuBisCo because PEPcase does not bind to the oxygen. But RuBisCo binds with oxygen and does the photorespiration, which is a harmful and wastage process and leads to decrease in photosynthetic yields

185 (a) RuBisco (Ribulose, 1-5 biphosphatase carboxylase and oxygenase) is the main critical enzymes in

photosynthetic carbon fixation.  $Mg^{2+}$  is an activator of RuBisCo

186 (a) The phenomenon of photolysis of water during photosynthesis is associated with photosystem-II and catalysed by presence of  $Mn^{2+}$  and  $Cl^-$  ions. When PS-II is active, the water molecules split into  $OH^-$  and  $H^+$  ions.

187 (b) RuBisCo. RuBisCo is the most abundant enzyme in the world. It is characterised by the fact that active sites can bind to both  $CO_2$  and  $O_2$ . This binding is competitive. It is the relative concentration of  $O_2$  and  $CO_2$  that determines, which of two ( $CO_2$  and  $O_2$ ) will bind to enzyme

188 (a) **Dicker** and **Tio** (1959) discovered photorespiration in tobacco plant. It is a light dependent process of oxygenation of ribulosebisphosphate (RuBP). During this process, carbon dioxide is liberated and oxygen is consumed.  $C_4$ -plants avoid photorespiration by following Hatch-Slack pathway.

189 (d) Flow of electrons in the non-cyclic photophosphorylation is always unidirectionally, from PS-II to the PS-I

190 (b) **Joseph Priestley** (1733-1804) in 1770 performed a series of experiment that revealed the essential role of air in growth of green plant. He also discovered oxygen in 1774

191 (d) Pigment system-II (PS-II) has absorption maxima at 680 nm and is called  $P_{680}$ .

192 (c) Mesophyll cells and bundle sheath cells which are connected through plasmodesmata, through which organic acid like malic acid, pyruvic acid can translocate. Malic acid translocate from the mesophyll cells to bundle sheath cell and pyruvic acid translocate from the bundle sheath cells to mesophyll cells

193 (c) The light intensity at which a plant can achieve maximum amount of photosynthesis is called saturation point

194 (b)



- Sunken stomata are usually found in crassulacean acid metabolic plants. Such automata remain situated below the epidermis and open at night.
- 195 (b) In  $C_4$ -plants the Calvin cycle takes place in bundle sheath cells
- 196 (b) The  $C_3$ -plant shows optimum photosynthesis at high  $CO_2$  concentration
- 197 (b) During  $C_4$ -cycle, the first  $C_4$  acid formed is oxaloacetic acid in chlorophyll of mesophyll cells. Then this oxaloacetic acid changes into another  $C_4$  acids like malic and aspartic acid in mesophyll and bundle sheath cells respectively
- 198 (a) Reduction of  $NADP^+$  to NADPH occurs during non-cyclic Photophosphorylation of light reaction, while oxidation of NADPH takes place during Calvin cycle.  
Teporphyrin ring of chlorophyll a flat, square, structure of alternating single and double bonds containing four smaller pyrrole rings with a magnesium atom at the centre.
- 199 (c)  $C_4$ -plants have Kranz anatomy in their leaves. In this leaf, the vascular bundle is surrounded by bundle sheath and mesophyll cells. Chloroplasts in the bundle sheath cells lack grana, while mesophyll chloroplasts are normal, e.g. *sugarcane*, *maize*, *Euphorbia*, *Amaranthus*, *Sorghum*, *Portulaca* and *Chenopodium*.
- 200 (b) *Oscillatoria* is a photosynthetic cyanobacterium. In this, photosynthesis water is electron donor and oxygen is a byproduct, i.e., oxygenic photosynthesis occurs. *Rhodospirillum* and *Chlorobium* are non-oxygenic photosynthetic, purple non-sulphur and green-sulphur bacteria. *Chromatium* is purple sulphur bacterium and also non-oxygenic photosynthetic.
- 201 (c)  $C_4$ -plants are special They have a special type of leaf anatomy, they tolerate higher temperature, they show a response to high light intensities, they lack a process called photorespiration and have greater productivity of biomass
- 202 (c) Most of the photosynthesis takes place in blue and red region
- 203 (b) The addition of  $NaHCO_3$  to water in the given experimental set-up causes the availability of more carbon dioxide for photosynthesis. Thus, amount of oxygen evolved increases.
- 204 (a) Cornelius van Niel (1897-1985) who based on his studies on purple and green bacteria, demonstrated that photosynthesis is essentially a light dependent reaction in which hydrogen from a suitable oxidisable compound reduces carbon dioxide to carbohydrate. This can be expressed by
- $$2H_2A + CO_2 \xrightarrow{\text{Light}} 2A + CH_2O + H_2O$$
- In green plants,  $H_2O$  is the hydrogen donor and is oxidised to  $O_2$  photosynthesis. Some organism do not release  $O_2$  during photosynthesis. When  $H_2S$  instead is the hydrogen donor for purple and sulphur bacteria, the oxidation product is sulphur or sulphate depending on the organism and not  $O_2$ . Hence, he inferred that  $O_2$  evolved by green plant comes from  $H_2O$ , not from carbon dioxide
- 205 (d) Ruben and Kamen (1941) and Ruben *et al* (1941) suspended *Chlorella* in water having non-radioactive heavy isotope of oxygen  $^{18}O$ , instead of natural oxygen ( $^{16}O$ ). The suspension was illuminated. Oxygen evolved was tested by means of mass spectrometer. It was found to be having isotope,  $O^{18}$ . This is possible only if, oxygen evolved during photosynthesis comes from splitting of water
- $$6CO_2 + 12H_2O^{18} \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6H_2O + 6O_2^{18}$$
- 206 (d) Photosystem-I is located on both the non-appressed part of grana thylakoids as well as stroma thylakoids, while photo system-II is located in the appressed part of the grana thylakoids.
- 207 (a) A possible location for the cyclic phosphorylation is the stroma lamellae because stroma lamellae lacks PS-II as well as the NADP reductase enzyme
- 208 (d) Plastocyanin is a small (10.5 KDa), water soluble, copper containing protein that transfer electrons between the cytochrome- $b_6 - f$  complex and  $P_{700}$ .
- 209 (d)

During phosphorylation, the chloroplast stroma is less acidic than the interior of thylakoid membrane because accumulation of protons during electron transport chain occurs in the lumen of thylakoid

210 (c)

Ribulose bisphosphate carboxylase oxygenase and phosphoenol pyruvate carboxylase are critical enzymes in photosynthetic carbon fixation.  $Mg^{2+}$  is an activator for both the enzymes?

211 (b)

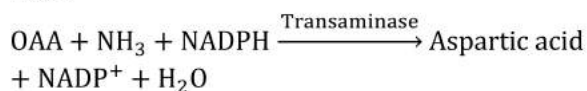
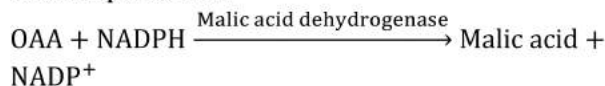
In 1939, **Robin Hill** demonstrated photolysis of water by isolated chloroplast in the presence of suitable electron acceptor.

212 (c)

Ottowarburg made an observation that  $O_2$  inhibits photosynthesis in  $C_3$ -plants. This phenomenon is originally known as the Warburg effect. It was later recognised as the light dependent release of  $CO_2$  due to oxygenase activity of RuBisCo called photorespiration

213 (b)

After the fixing of  $CO_2$  to Oxaloacetic Acid (OAA) in  $C_4$  cycle, the oxaloacetic acid changes into the malic aspartic acid



Both of these reactions occur in mesophyll cell

214 (b)

The portion of spectrum between 400-700 nm is referred to as Photosynthetically Active Radiation. Manganese and chloride ions play prominent role in photolysis of water.

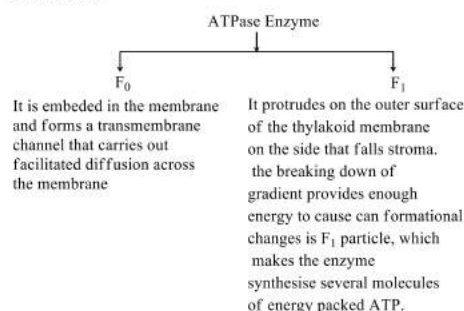
215 (b)

ATP is synthesised by cells (in mitochondria and chloroplasts) and the process is named as phosphorylation. Photophosphorylation is the synthesis of ATP from ADP and inorganic phosphate in the presence of light. When the two photosystems work in a series, first PS-II and then the PS-I, a process called non-cyclic photophosphorylation occurs. The two photosystem are connected through an electron transport chain, as seen earlier- in the Z scheme. Both ATP and  $NADPH + H^+$  are synthesised by this kind of electron flow. When only PS-I is

functional, the electron is circulated within the photosystem and the phosphorylation occurs due to the cyclic flow of electrons

216 (b)

I and II.



217 (d)

Chemiosmosis requires a membrane, a proton pump, a proton gradient for making ATP through ATPase enzyme

218 (a)

Biosynthetic phase of photosynthesis depends on the NADPH and ATP. Both are used directly in the synthesis of glucose.

The energy required to hydrolyse the water comes from oxidising chlorophyll. Oxidation of chlorophyll occurs due to the release of high energy electrons from the chlorophyll

219 (d)

Kranz anatomy is characteristic of  $C_4$ -plants. The vertical section of leaves of  $C_3$  and  $C_4$  show differences. The  $C_4$  leaves have particularly large cells around the vascular bundles of  $C_4$  pathway plants called bundle sheath cells and the leaves which have such kind of anatomy are said to have 'Kranz-anatomy'. 'Kranz' means wreath and is reflection of arrangement of cells

220 (a)

The process of photorespiration involves the involvement of chloroplasts, peroxisomes and mitochondria. Biochemical mechanism for photorespiration is also called **glycolate cycle**.

221 (b)

Photosynthesis (*photos-light, synthesis*-putting together) is an anabolic process of manufacturing organic compounds inside the chlorophyll containing cells from carbon dioxide and water with the help of sunlight as the source of energy

222 (c)

Beyond the saturation point (seldom seen in  $C_4$ -plants), the rate of photosynthesis begins to decline. This process is called solarisation. It is

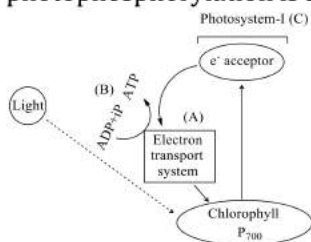
due to the reduction in hydration and closure of stoma (photo-inhibition) or oxidation of photosynthetic pigment (photooxidation)

223 (b)

A chemical substance, when irradiated with UV rays, absorbs radiation and emits visible light is called **fluorochrome**.

224 (b)

In cyclic photophosphorylation, only PS-I is functional and the formation of ATP takes place (not NADPH). The possible location of cyclic photophosphorylation is stroma lamella



225 (a)

Chlorophylls are magnesium porphyrin compounds. Chlorophyll-*a* (C<sub>55</sub>H<sub>72</sub>O<sub>6</sub>N<sub>4</sub>Mg) and chlorophyll-*b* (C<sub>55</sub>H<sub>70</sub>O<sub>6</sub>N<sub>4</sub>Mg), both consist of magnesium porphyrin head, which is hydrophilic and a phytol tail, which is lipophilic but chlorophyll-*b* differs from chlorophyll-*a* only in one of the functional groups bonded to porphyrin. Actually in chlorophyll-*b*, there is -CHO (aldehyde) group instead of -CH<sub>3</sub> (methyl) group at the third C-atom in second pyrrole ring.

226 (b)

PAR (Photosynthetically active radiation) designates the spectral range of solar radiation from 400 to 700 nm that photosynthetic organisms are able to use in the process of photosynthesis. Of the total incident solar radiation the proportion of PAR is less than 50%

227 (c)

Using a similar set up as used by Priestley but by placing it once in a dark and once in a sunlight, Jan Ingen Housz (1730-1799) showed that sunlight is essential to plant process that purifies air

228 (c)

Glucose is a hexose sugar. It's one molecule contains six carbon atoms. As Calvin cycle takes in only one carbon (as CO<sub>2</sub>) at a time, six turns of this cycle will be required to produce one molecule of glucose (6C).

Hence, for producing 5 molecules of glucose (30 molecules of carbon), 30 turns of Calvin cycle are required.

229 (b)

During the light reaction

(i) Formation of ATP from ADP takes place or phosphorylation of ADP to ATP takes place

(ii) Reduction of NADP<sup>+</sup> to NADPH + H<sup>+</sup> takes place by PS-I through electron transport system

230 (d)

ATP made when energy is used to bond another phosphate to ADP, a process called

**phosphorylation**. In photosynthesis, the energy is supplied by light and the process is, therefore, called **photophosphorylation**.

231 (b)

TW Engelmann (1843-1909) performed an interesting experiment using a prism. He split light into its spectral components and then illuminated a green alga, *Cladophora*, placed in a suspension of aerobic bacteria.

The bacteria were used to detect the sites of O<sub>2</sub> evolution. He observed that the bacteria accumulated mainly in the region of blue and red light of the split spectrum. A first action spectrum of photosynthesis was thus described

232 (a)

Julius von Sachs provided evidence for the production of glucose when plants grow. Glucose is usually stored as starch. His later studies showed that the green substance in plants (chlorophyll as we know it now) is located in special bodies (later called chloroplast) within plant cells.

He found that the green parts in plants are where glucose is made, and that the glucose is usually stored as starch

233 (d)

Calvin cycle (C<sub>3</sub>-cycle) was discovered by **Calvin, Benson** and their associates, which fed *Chlorella* and *Scenedesmus* with radioactive carbon (C<sup>14</sup>) in carbon dioxide.

234 (b)

The movement of electrons in ETS of photosynthesis is down hill in terms of oxidation reduction or redox potential scale. The electrons are not used up as they pass through the electron transport chain, but they passed on the pigments of photosystem I. Simultaneously, electrons in the reaction centre of PS-I are also excited, when they

receive red light of wavelength 700 nm and are transferred to another acceptor molecule that has greater redox potential. These electrons then are moved down hill again this time to a molecule of energy rich NADP<sup>+</sup>. The addition of these electrons reduces the NADP<sup>+</sup> to NADPH + H<sup>+</sup>

235 (b)

When P<sub>r</sub> absorbs red light (660-665 nm) it is converted into P<sub>fr</sub> from and when P<sub>fr</sub> absorbs far red light (730-735 nm) it is converted into P<sub>r</sub> from.

236 (d)

Kranz anatomy is a characteristic feature of the leaves of C<sub>4</sub>-plants like sugarcane, maize, etc. in this type of anatomy, mesophyll cells are not differentiated into spongy and palisade cells and have chloroplasts with large grana. These are involved in the initial fixation of carbon dioxide. Bundle sheath chloroplasts are large and agranal and are highly efficient in carbon dioxide fixation, therefore, abundant starch grains are produced in these cells.

237 (a)

In the matrix or stroma, there are embedded a number of flattened membranous sacs called thylakoids or lamellae. Membranes of thylakoids are called fret membranes. They are made up of both proteins and unsaturated lipids, roughly in the ratio of 50:50

238 (b)

C<sub>4</sub>-plants are more efficient in photosynthesis than C<sub>3</sub>-plants but use more energy. They possess the larger number of chloroplasts in the leaf cells. In the leaves of C<sub>4</sub>-plants, the vascular bundles are surrounded by bundle sheath of larger parenchymatous cells, which in turn are surrounded by mesophyll cells. Chloroplasts in bundle sheath cells are larger and always contain grana, whereas chloroplasts in mesophyll cells are smaller.

239 (a)

RuBPCarboxylase (RUBISCO) is the most abundant protein in chloroplasts and probably on earth. It catalyses the carboxylation of ribulose 1-5 bisphosphate to form two molecules of 3-phosphoglyceric acid in C<sub>3</sub>-cycle of photosynthesis.

240 (c)

During the photolysis of water, the release of electrons, protons and oxygen takes place.

Reaction during the photolysis of water is follows  
 $2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{O}_2 + 4e^-$

241 (a)

Kranz anatomy, *i.e.*, chloroplast containing mesophyll cells and bundle sheath cells. The phosphoenol pyruvate in mesophyll cells combine with CO<sub>2</sub> in presence of PEP carboxylase and forms oxaloacetic acid and large bundle sheath are the characters of C<sub>4</sub> plants

242 (c)

In the leaves of C<sub>4</sub>-plants, the bundle sheath consists of thick walled cylindrical cells. These cells have a granal chloroplast so density is low

243 (b)

Scheme of transfer of electrons, starting from the PS-II, uphill to the acceptor, down the electron transport chain to PS-I, excitation of electrons, transfer to another acceptor and finally down hill to NADP<sup>+</sup> causing it to be reduced to NADPH + H<sup>+</sup> is called the Z scheme, due to its characteristic shape. This shape is formed when all the carriers are placed in a sequence on a redox potential scale

244 (b)

Photophosphorylation in chloroplast is similar to the mitochondrial oxidative phosphorylation. In both of them, the proton gradient plays a significant role in chloroplast the proton gradient develops in the lumen and in mitochondria the proton gradient develops in the intermitochondrial space. Rest of the mechanism of phosphorylation remains the same in both the organelle

246 (b)

As a result of light reaction, oxygen, NADPH and ATP are formed. Oxygen is released into the atmosphere, while NADPH and ATP are utilised for reduction of carbon dioxide to carbohydrate in dark reaction.

247 (a)

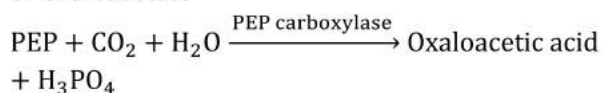
At the low CO<sub>2</sub> and high O<sub>2</sub> concentration RuBisCo oxygenase activity increases. Binding with oxygen leads to the formation of 2-phosphoglycolate and 3 phosphoglycerate

248 (b)

In C<sub>4</sub>-plants the initial fixation of carbon dioxide occurs in mesophyll cell. The primary acceptor of CO<sub>2</sub> is phosphoenol pyruvate or PEP. It combines with carbon dioxide in presence of PEP



carboxylase or PEPcase to form oxaloacetic acid or oxaloacetate

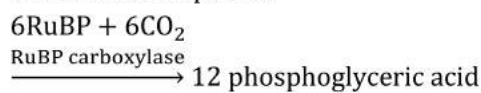


249 (a)

The vertical section of leaves of  $C_3$  and  $C_4$  show differences. The  $C_4$  leaves have particularly large cells around the vascular bundles of  $C_4$  pathway plants called bundle sheath cells and the leaves which have such kind of anatomy are said to have 'Kranz-anatomy'. 'Kranz' means wreath and is reflection of arrangement of cells

250 (b)

Dark phase of photosynthesis or Calvin cycle takes place in stroma of chloroplast. First step of dark phase is Carboxylation. In Carboxylation, carbon dioxide is combined with RuBP to form first stable compound.



NADP<sup>+</sup> acts as hydrogen acceptor.

251 (b)

The Calvin cycle occurs in the stroma of chloroplast of  $C_3$  plants and consists of three main parts, i.e., carboxylation, reduction and regeneration. Carboxylation involves addition of carbon dioxide to ribulose 1,5-bisphosphate in presence of RUBISCO enzyme to form 3-PGA (3-phosphoglyceric acid), i.e., single carboxylation occurs in Calvin cycle.

252 (a)

Plants adapted to low light intensity have larger photosynthetic unit size than the sun plants.

253 (a)

Oxygen evolves by the oxidation of water molecule in the process called photosynthesis. Thus, if water is  $O^{18}$  labelled then oxygen liberated by process called photosynthesis must also be labelled

254 (a)

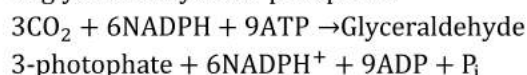
Algae (*Clodophora*).

Julius von Sachs provided evidence for the production of glucose when plants grow. Glucose is usually stored as starch. His later studies showed that the green substance in plants (chlorophyll as we know it now) is located in special bodies (later called chloroplast) within plant cells.

He found that the green parts in plants are where glucose is made, and that the glucose is usually stored as starch

255 (d)

Three molecules of carbon dioxide must be converted to glyceraldehydes 3-phosphate (three carbon molecules), three ATP and two NADPH are required for each carbon dioxide to be converted to glyceraldehydes-3-phosphate.



256 (d)

Product of light reactions are ATP, NADPH and  $O_2$ . Of these  $O_2$  diffuse out of the chloroplast, while ATP and NADPH are used to drive the process leading to synthesis of food, sugars. NADPH +  $H^+$ ,  $O_2$ , etc.

257 (b)

There is a point in the light intensity, where there is no gaseous exchange in photosynthesis. It is called light compensation point

258 (b)

During the dark reaction the acceptor of  $CO_2$  is RuBP (Ribulose 1-5 diphosphate). After accepting, it forms the intermediately six carbon compound, which breaks down into two three carbon stable compound. It is called 3 PGA

259 (b)

The first reaction of photorespiration occurs in **stroma** of chloroplast. In this reaction, the RuBP (Ribulose 1, 5-biphosphate) consumes one oxygen molecules in presence of enzyme RUBISCO. In **peroxisome**, the glycolate transferred from chloroplast, takes up oxygen and formed the glyoxylate whereas the  $H_2O_2$  release as byproduct.

260 (d)

Phosphorylation refers to the process, in which ATP is made, when energy is used to bond another phosphate to ADP. In photosynthesis, they energy is supplied by light and the process is, therefore, called photophosphorylation.

261 (a)

Due to the difference in the pH of the two medium (outside and inside), there is development of proton gradient, which leads to the formation of ATP

263 (d)

If light becomes unavailable then the biosynthetic phase continues for sometime and then stops.



Product of light reactions are ATP, NADPH and  $O_2$ . Of these  $O_2$  diffuse out of the chloroplast, while ATP and NADPH are used to drive the process leading to synthesis of food, sugars.  $NADPH + H^+$ ,  $O_2$ , etc.

264 (d)

During photosynthesis, the proton accumulation is towards the inside of the membrane, *i.e.*, in the lumen. In respiration, protons accumulate in the intermembrane space of the mitochondria when electrons move through the ETS

265 (c)

The  $C_4$ -plants have **dimorphic chloroplasts-granal** and **agranal**. Chloroplasts in mesophyll cells are granal, *i.e.*, they contain thylakoids that are stacked to form grana, as in  $C_3$  -plants. Chloroplasts of **bundle sheath cells** are agranal, *i.e.*, grana are absent and the thylakoids are present only as stroma lamellae.

266 (d)

The uses of radioactive  $^{14}C$  by Malvin-Calvin in algal (*Chlorella*) photosynthesis studies, led to the discovery that first carbon dioxide fixation product was 3-carbon organic acid. This first product was identified as 3-Phosphoglyceric Acid (3PGA)

267 (d)

**Hill's reaction**/photochemical/light reaction is initiated when specific light is absorbed by group of chlorophyll molecules primarily concerned with light harvesting.

268 (a)

Fixing of one molecule of  $CO_2$  or carbon needs 5 ATP and 2 NADPH in  $C_4$ -plants.  $C_4$ -plants takes 2 more ATP than  $C_3$ -plants. But, the photorespiration is absent in  $C_4$ -plants, thus  $C_4$ -plants are more economical than  $C_3$ -plant

269 (d)

$CO_2$  is required for photosynthesis is demonstrated by half-leaf experiment in which a part of a leaf is enclosed in a test tube containing some KOH soaked cotton (which absorbs  $CO_2$ ), while the other half is exposed to air. The setup is then placed in light for some time. On testing for starch later in the two halves of the leaf, the exposed part of the leaf tested positive for starch while the portion that was in the tube, tested negative. This showed that  $CO_2$  is required for photosynthesis

270 (b)

Pineapple is a CAM (Crassulacean Acid Metabolic) plant, in this, the process of photosynthesis takes place in two different places, *i.e.*, light and dark

271 (a)

For every  $CO_2$  molecule entering the Calvin cycle, 3 molecule of ATP and 2 molecule of NADPH are required. The difference in the number of ATP and NADPH used in dark reaction is overcome by cyclic phosphorylation

272 (d)

Proton gradient is important because it is the break down of this gradient that leads to release of energy. The gradient is broken down due to movement of protons across the membrane to the stroma through the transmembrane channel of the  $F_0$  of the ATPase.

The energy released during the breaking down of proton gradient is used in formation of ATP

273 (d)

**Plastoquinone** is the first acceptor of electrons from an excited chlorophyll molecule of photo system-II.

274 (a)

Cytochromes are iron containing pigments. These acts as electron transporter or electron acceptor in respiration and photosynthesis

275 (a)

Oxaloacetic acid is a  $^4C$ -compound. In  $C_4$ -plants, oxaloacetic acid is the first carbon dioxide fixation product.

276 (a)

Action spectrum.

Though chlorophyll-*a* is the major pigment responsible for trapping light, other thylakoid pigments like chlorophyll-*b*, xanthophylls and carotenoids, which are called accessory pigments, also absorb light and transfer the energy to chlorophyll-*a*. Indeed, they not only enable a wider range of wavelength of incoming light to be utilised for photosynthesis but also protect chlorophyll-*a* from photooxidation

277 (b)

A-with, B-decrease. Water stages leaves with thus reducing the surface area of leaves and their metabolic activity as well

278 (c)

Even after the closing, the stomata of  $C_4$ -plants performs photosynthesis because they can produce their own  $CO_2$  by decarboxylation of



- malic acid, which is used in Calvin cycle like in  $C_3$ -plants
- 279 **(d)**  
Photorespiration is the uptake of oxygen and release of carbon dioxide in light that results from the biosynthesis of glycolate in chloroplast and subsequent metabolism of glycolic acid in the same leaf cell through other two cell organelles (*i.e.*, peroxisome and mitochondria). Conversion of phosphoglycolate to glycolate takes place in **chloroplast**.
- 280 **(a)**  
The chemical formula of starch is  $(C_6H_{10}O_5)_n$ .
- 281 **(c)**  
**Emerson *et al.*** (1957) discovered that far red light (above 680 nm), which is Photosynthetically inefficient can be made efficient by supplementing it with a beam of shorter wavelength (red beam below 680 nm). Further the quantum yield in combined beam (far red+red) is more than sum total of quantum yields in two separate beam. This enhancement in quantum yield by supplementing far red light with red light is called **Emerson enhancement effect**.
- 282 **(b)**  
Carotenoids are a group of yellow, red and orange pigments, which function as accessory pigments and protect chlorophyll molecules from destruction by intensive light rays. Carotenoids have three absorption peaks in the **blue-violet** range of the spectrum.
- 283 **(b)**  
The fixation of carbon dioxide in  $C_4$ -plants takes place in two places and by two different organic compounds. Phosphoenol pyruvate (PEP) is found in mesophyll cells, which primarily fixes atmospheric carbon dioxide into oxaloacetic acid (4C). RUBISCO is present in bundle sheath cells, where final fixation of carbon dioxide in hexose sugar takes place. Carbon dioxide is primarily fixed by PEP carboxylase because this enzyme has greater affinity to carbon dioxide than RUBISCO.
- 284 **(b)**  
CAM plants store large quantities of  $CO_2$  at night and release it later during the day for use by the photosynthetic carbon reduction cycle.  
**Example- *Kalanchoe, Agave, Opuntia*, etc.**
- 285 **(a)**  
RuBP (Ribulose, 1-5 diphosphate) is the 5 carbon compound in which the ribose sugar is present
- 286 **(d)**  
The membranous system is responsible for trapping the light energy that make ATP and NADPH necessary for the starch synthesis
- 287 **(a)**  
Photophosphorylation is differ from oxidative phosphorylation in requiring the input of energy in the form of light to create a good electron donor.
- 288 **(b)**  
Cyclic phosphorylation occurs only when wavelength beyond 680 nm is available for excitation.  
Non-cyclic phosphorylation occurs in the membrane or lamellae of grana. Because membrane or lamellae of grana have both photosystem (PS-I and PS-II) and in non-cyclic phosphorylation both PS-I and PS-II participates
- 289 **(a)**  
Cytochrome are the electrons carrier between the PS-II to PS-I in photosynthesis. If there is a mutation in cytochrome then the movements of electrons from PS-II to PS-I is inhibited
- 290 **(a)**  
 $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$
- 291 **(b)**  
Photolysis of water means breakdown of water in the presence of sun light. This generates oxygen. Photolysis of water takes place in light reaction and it requires **chloride** and **manganese** ions as catalyst.
- 292 **(d)**  
Excited simultaneously with PS-II ( $P_{680}$ ).  
The movement of electrons in ETS of photosynthesis is down hill in terms of oxidation reduction or redox potential scale. The electrons are not used up as they pass through the electron transport chain, but they passed on the pigments of photosystem I. Simultaneously, electrons in the reaction centre of PS-I are also excited, when they received red light of wavelength 700 nm and are transferred to another acceptor molecule that has greater redox potential. These electrons than are moved down hill again this time to a molecule of energy rich  $NADP^+$ . The addition of these electrons reduces the  $NADP^+$  to  $NADPH + H^+$
- 293 **(a)**  
In low carbon dioxide concentration, glycolic acid or glycolate is formed, which is the substrate for

- photorespiration or  $C_2$ -cycle or glycolate metabolism.
- 294 **(c)**  
Usually, the chloroplasts align themselves along the walls of mesophyll cells, such that they get the optimum quantity of the incident light
- 295 **(b)**  
Photorespiration required chloroplast, mitochondria and peroxisome to complete the process. At high temperature and high oxygen concentration, RuBPOxygenase oxidizes RuBP to produce phosphoglycolate then glyoxylate and then glycine. Two glycine molecule in addition to  $\alpha$ -ketoglutarate produce serine molecule. Therefore, to produce 20 serine molecules, 40 RuBP molecules are required.
- 296 **(d)**  
In Calvin cycle, ribulose 1-5 biphosphate ultimately produces two molecules of 3 PGAL, *i.e.*, total 6 molecules by three Calvin cycles. In the same one ATP for each 3 PGAL molecules is phosphorylated (Total 6 ATP).
- 297 **(a)**  
In  $C_4$ plants, primary  $CO_2$ acceptor is 3C-compound, phosphoenol pyruvate (PEP) and is present in the mesophyll cells. The enzyme responsible for this fixation is PEP carboxylase or PEPcase.
- 298 **(a)**  
CAM plants fix  $CO_2$ at night and from malate which stored in large vacuole of mesophyll cells till next day. These plants use PEP carboxylase. The malate release  $CO_2$  in day for use in Calvin cycle in same cell, e.g., family-Euphorbiaceae, Asclepiadaceae, etc.
- 299 **(a)**  
A- $C_3$ , B-2, C-5
- 300 **(d)**  
PS-I (photosystem-I) is a photosynthetic pigment system along which some electron carriers that is located on both the non-appressed parts of grana thylakoids as well as stroma thylakoids.  
PS-II (Photosystem-II) is the photosynthetic pigment system along with some electrons carriers that is located in the appressed part of grana thylakoid
- 301 **(a)**  
Calling the biosynthetic phase as the dark reaction is misnomer because without the light, the dark reaction cannot sustain for long. For the sake of simplicity, it is been called dark reaction
- 302 **(c)**  
About 42% of solar radiation hits the earth's atmosphere.
- 303 **(b)**  
The  $CO_2$  formed in the bundle sheath cells by decarboxylation of malic acid used in the Calvin cycle. In that way,  $C_4$ -plants have their own  $CO_2$  for the Calvin cycle. That's why  $C_4$ -plants can perform Calvin cycle even in very low  $CO_2$  concentration
- 304 **(c)**  
Photophosphorylation is the formation of ATP from ADP and inorganic phosphate in the presence of light. When the two phosphates work in a series. (first PS-II and then PS-I) then non-cyclic photophosphorylation occurs.  
The two photosystems are connected through an electron transport chain. Both ATP and NADPH are synthesised by this kind of electron flow
- 305 **(b)**  
ATP is formed during photophosphorylation. Water does takes part in photosynthesis-oxygen comes from water not from carbon dioxide.
- 306 **(b)**  
Cytochrome oxidase is an **endoenzyme**. This enzyme plays very important role in ETS of photosynthesis as well as respiration.
- 307 **(c)**  
 $NADP^+$  to  $NADPH + H^+$ .  
During the light reaction  
(i) Formation of ATP from ADP takes place or phosphorylation of ADP to ATP takes place  
(ii) Reduction of  $NADP^+$  to  $NADPH + H^+$  takes place by PS-I through electron transport system
- 308 **(a)**  
Cytochroma oxidase is an iron-containing key enzyme of mitochondrial respiration. Cytochrome oxidase (complex IV) is a large enzyme of inner mitochondrial membrane.
- 309 **(d)**  
Kranz anatomy shows presence of rudimentary chloroplasts in bundle sheath cells and typical granal chloroplasts in mesophyll cells.
- 310 **(a)**  
Oxaloacetic acid.  
Plants that are adapted to dry tropical regions generally have the  $C_4$  pathway. Though these plants have the  $C_4$ -oxaloacetic acid as the first  $CO_2$



- fixation product they use the C<sub>3</sub> pathway or the Calvin cycle as the main biosynthetic pathway
- 311 (d) **Photochemical reaction** is also known as **light reaction** because it takes place in the presence of light in the grana portion of chloroplast. In this reaction, photolysis of water takes place, which generates oxygen, simultaneously, **photophosphorylation** takes place which generates ATP and NADPH.
- 312 (b) C<sub>4</sub>-plants utilise solar energy more efficiently because photosynthesis rate is very high in C<sub>4</sub>-plants, *e.g.*, **sugarcane, maize**, etc.
- 313 (a) ATP and NADPH are consumed in the dark reaction for the formation of carbohydrates or starch with the help of RuBP
- 314 (b) Mitochondria and chloroplast are the organelle, which forms ATP in the living system. In both the system the electron transport system is present through, which electrons are carried by carrier molecule down hill to redox. That's way carrier molecules are oxidised or reduced in chloroplast and mitochondria
- 315 (b) The electrons that were moved from photosystem II must be replaced. This is achieved by electrons available due to splitting of water. The splitting of water is associated with the PS-II. Water is split into H<sup>+</sup>, O and electrons. This creates oxygen, one of the net products of photosynthesis. The electrons that are needed to replace those removed from photosystem-I are provided by photosystem-II  

$$2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + \text{O}_2 + 4e^-$$
- 316 (c) The pigments are organised into two discrete photochemical Light Harvesting Completes (LHC) within the Photosystem I (PS-I) and Photosystem II (PS-II). These are named in the sequence of their discovery, and not in the sequence in which they function during the light reaction. The LHC are made up of hundreds of pigment molecules bounded to proteins. Each photosystem has all the pigments (except one molecule of chlorophyll-*a*) forming a light harvesting system known as antenna
- 317 (c)
- Glucose phosphates formed in photosynthesis are asymmetrically labelled, it is called **Gibb's effect**.
- 318 (a) Steps that causes proton gradient to develop during photophosphorylation are as follows  
 (i) protons or hydrogen ions that are produced by the splitting of water accumulates within the lumen of the thylakoids  
 (ii) As electrons move through the photosystems, protons are transported across the membrane. This, happens because the primary acceptor of electron, which is located towards the outer side of the membrane transfers its electrons not to an electron carrier but to an H<sup>+</sup> carrier. Hence, this molecule removes a proton from stroma, while electrons transporting  
 (iii) The NADP reductase enzyme is located on the stroma side of the membrane. Along with electron, reduction of NADP<sup>+</sup> to NADPH + H<sup>+</sup> takes place. By this way, the proton removes from stromal side of the thylakoid.  
 Proton gradient is important because it is the break down of this gradient that leads to release of energy. The gradient is broken down due to movement of protons across the membrane to the stroma through the transmembrane channel of the F<sub>0</sub> of the ATPase.  
 The energy released during the breaking down of proton gradient is used in formation of ATP
- 319 (a) Chlorophyll-*a*.  
 The pigments are organised into two discrete photochemical Light Harvesting Completes (LHC) within the Photosystem I (PS-I) and Photosystem II (PS-II). These are named in the sequence of their discovery, and not in the sequence in which they function during the light reaction. The LHC are made up of hundreds of pigment molecules bounded to proteins. Each photosystem has all the pigments (except one molecule of chlorophyll-*a*) forming a light harvesting system known as antenna
- 320 (c) Oxygen and release of CO<sub>2</sub> takes place.  
 Photorespiration is a light dependent utilisation of oxygen and release of carbon dioxide by photosynthetic organs of plant. Normally, photosynthetic organs do the reverse in the light, *i.e.*, uptake of CO<sub>2</sub> and release of O<sub>2</sub>
- 321 (a)

- Chlorophyll-*a* is found in all photosynthetic plants. Hence, it is termed as universal photosynthetic pigment. Bacteriochlorophyll are present in bacteria and bacteriochlorophyll-*a* resembles with chlorophyll-*a* in plants
- 322 **(b)**  
(i) PS-I has more (about twice) chlorophyll-*a* than chlorophyll-*b*. PS-II has about equal amount of chlorophyll-*a* and chlorophyll-*b*
- 323 **(a)**  
All animals including human beings depend on plants for their food. Green plants synthesize the food they need and all other organisms depend on them for their needs. Green plants carry out photosynthesis, a **physico-chemical** process by which they use light energy to drive the synthesis of organic compounds
- 324 **(d)**  
In  $C_4$ -plants, chloroplasts are found in both bundle sheath and mesophyll cells. Chloroplasts in bundle sheath cells are larger and does not contain grana, whereas chloroplasts in mesophyll cells are smaller and have grana.
- 325 **(b)**  
All the life forms are supported by the plants, whether, it is herbivore or carnivore. Chloroplast present in plants traps the solar energy and changes it to starch. This process is called photosynthesis. So, we are created by chloroplast means that all life forms depends on photosynthesis
- 326 **(c)**  
 $C_4$ -plants are characterized by Kranz type of anatomy, i.e., chloroplast containing mesophyll cells and bundle sheath cells. The phosphoenol pyruvate in mesophyll cells combine carbon dioxide in presence of PEP carboxylase and forms oxaloacetic acid. The product of photosynthesis is starch.
- 327 **(c)**  
HMP pathway occurs in **cytoplasm** of cell.
- 328 **(c)**  
The energy required to hydrolyse the water comes from oxidising chlorophyll. Oxidation of chlorophyll occurs due to the release a high energy electrons from the chlorophyll
- 329 **(b)**  
The chloroplasts in  $C_4$ -plants are dimorphic (two morphologically distinct types). The chloroplasts of bundle sheath cells are large in size and arranged centripetally. They mesophyll cells, on the other hand, contain normal type of chloroplasts.
- 330 **(b)**  
PS-I is driven by far red light and PS-II by red light. The main components of PS-I are chl.-*a* ( $P_{700}$ ), chl.-*b* and  $\beta$ -carotene.
- 331 **(d)**  
Along with the NADPH produced by the movement of electrons, the ATP will be used immediately in the biosynthetic reaction taking place in the stroma, responsible for fixing  $CO_2$  (reduction) and synthesis of sugars
- 332 **(b)**  
Electron excited by PS-I used in the formation of  $NADPH + H^+$ . These electrons come ultimately from  $H_2O$  through photosynthesis
- 333 **(c)**  
Electrons during photosynthesis goes from the  $H_2O$  to the PS-II then by various cytochrome carrier. It reaches to PS-I then reaches to the  $NADP^+$  and reduces it in the presence of  $H^+$  to form  $NADPH + H^+$
- 334 **(b)**  
Photorespiration is the light dependent process, in which utilisation of oxygen and release of carbon dioxide by the photosynthetic organs of a plant takes place. Normally, photosynthetic organs are reverse in the light, i.e., uptake carbon dioxide and release oxygen. This process is pronounced in  $C_3$ -plants and negligible in  $C_4$ -plants. At high temperature, RuBP carboxylase functions as oxygenase and instead of fixing carbon dioxide, oxidises ribulose 1, 5-biphosphate to produce phosphoglyceric acid and phosphoglycolate (starting substrate). On hydrolyzing, it forms glycolate and then glyoxylate, glycine and serine respectively.
- 335 **(b)**  
Photosynthesis is the endergonic used, i.e., energy is used during physiochemical process in which the light gets converted into the high energy. Chemical bonds are used in the formation of sugar
- 336 **(c)**  
Compensation point refers to alight intensity at which the rate of respiration by a photosynthetic cell or organ is equal the rate of photosynthesis. There is no net gain or loss of oxygen or carbon dioxide from the structure.
- 337 **(a)**

- In Z-scheme of light reaction, the participating photosystem are PS-II and PS-I. Electrons are transported from PS-II to the PS-I through electron transport system by cytochromes
- 338 **(d)**  
Though chlorophyll-*a* is the major pigment responsible for trapping light, other thylakoid pigments like chlorophyll-*b*, xanthophylls and carotenoids, which are called accessory pigments, also absorb light and transfer the energy to chlorophyll-*a*. Indeed, they not only enable a wider range of wavelength of incoming light to be utilised for photosynthesis but also protect chlorophyll-*a* from photooxidation
- 339 **(b)**  
In CAM-plants, the stomata open at night. This allows the entry of carbon dioxide in the leaves. The carbohydrates stored in plants are converted to PEP by Glycolysis, which is carboxylated to malic acid. Thus, carbon dioxide is fused in plants as malic acid, which stored inside vacuole. In the day time, stomata close and the malate transported to chloroplast, undergoes decarboxylation and the released carbon dioxide is fixed by Calvin cycle.
- 340 **(c)**  
Water is one of the reactant in the light reaction. The effect of water on photosynthesis is seen in the stress condition when water availability is very low. Water is also produced in dark reaction of photosynthesis. Water stress causes the stomata to close hence reducing, the availability
- 341 **(d)**  
The site for photorespiration is chloroplast. RuBP carboxylase function as oxygenase and instead of fixing carbon dioxide, it convert oxidase ribulose 1-5 biphosphate (RuBP) to produce phosphoglycerate and phosphoglycolate
- $$\text{RuBP} + \text{O}_2 \xrightarrow[\text{Oxygenase}]{\text{RuBP}} \text{PGA} + \text{Phosphoglycolate}$$
- 342 **(d)**  
The pigments are organised into two discrete photochemical light harvesting complexes (LHC) within the photosystem-I (PS-I) and photosystem II (PS-II)
- 343 **(b)**  
Regeneration of PEP from pyruvate takes place in the bundle sheath cells and conversion of pyruvate in PEP takes plants in mesophyll cells
- $$\text{Pyruvate} + \text{ATP} \xrightarrow[\text{Kinase}]{\text{Phosphopyruvate}} \text{PEP} + \text{AMP} + \text{H}_3\text{PO}_4$$
- 344 **(d)**  
Pigments are substances that have an ability to absorb light at specific wavelength. Among all pigments, chlorophyll-*a* absorb the maximum wavelength in the blue and red region. In these region, the chlorophyll-*a* does the maximum photosynthesis. Thus, chlorophyll-*a* is called the main photosynthetic pigment
- 345 **(a)**  
In far-rad light (wavelength more than 680 nm), there is a reduction in the quantity of O<sub>2</sub> evolution.
- 346 **(a)**  
Photorespiration is the light dependent utilization of O<sub>2</sub> and release of CO<sub>2</sub> by photosynthetic organs of a plant Photo respiration involves chloroplast, Peroxisome and mitochondria to complete the process.
- 347 **(a)**  
In higher plants, enzymes for light independent reactions (dark reactions) are present in the stroma of chloroplasts. Light dependent reaction occurs in grana of chloroplast. **Ribosomes** are necessary for protein synthesis. **Chlorophyll** is green photosynthetic pigment found in chloroplasts.
- 348 **(d)**  
Carbon dioxide is the major limiting factor for photosynthesis. The concentration of CO<sub>2</sub> is very low in the atmosphere (Between 0.03 to 0.04% or 300-400 ppm). Increase in concentration up to 0.05% can cause an increase in CO<sub>2</sub> fixation rates. Beyond this, the levels can become damaging over longer periods
- 349 **(d)**  
Maximum photosynthesis occurs in the blue-violet and red region of light spectrum. Red light favours the carbohydrate accumulation, while blue light stimulates protein synthesis
- 350 **(c)**  
Maximum number of chloroplast is found in leaves
- 351 **(d)**  
C<sub>4</sub>-plants (maize) require 30 ATP and 12 NADPH for synthesis of one hexose molecule. Therefore, synthesis of six hexose molecules requires 180 ATP and 72 NADPH.

352 (c)

The first step in dark reaction of  $C_3$  plants is carboxylation of ribulose 1-5 biphosphate by atmosphere  $CO_2$  in presenic of enzyme, Rubisco to form PGA  
 $Ribulose\ 1-5\ biphosphate + CO_2 + H_2O \rightarrow 3\ PGA.$

353 (c)

The seed germination is promoted by red wavelength (650 nm), this is due to the pigment phytochrome behaving in the following manner.



354 (d)

**Ruben, Hassid and Kamen** proved that oxygen evolved in photosynthesis comes from water.

355 (a)

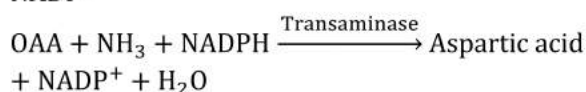
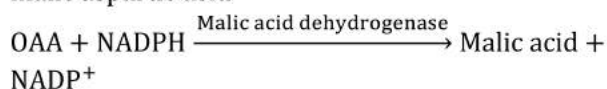
Compensation point refers to the light intensity, at which the rate of respiration by photosynthetic cell or organ is equal to the rate of photosynthesis. There is no net gain or loss of oxygen or carbon dioxide from the structure

356 (b)

Living organisms have the capability of extracting energy from oxidisable substances and store this the in form of bond energy. Special substances like ATP, carry this energy in their chemical bonds. The process through which ATP is synthesised by cells (in mitochondria and chloroplast) is named oxidative phosphorylation

357 (c)

Malic acid or aspartic acid is translocated to bundle sheath cells through plasmodesmata. Inside the bundle sheath cell they are decarboxylated (malic acid) or deaminated. In case of aspartic acid to form  $CO_2$  and pyruvate. After the fixing of  $CO_2$  to Oxaloacetic Acid (OAA) in  $C_4$  cycle, the oxaloacetic acid changes into the malic aspartic acid



Both of these reactions occur in mesophyll cell

358 (d)

Four pyrrole ring.  
Chlorophyll-*a*

359 (a)

The substrate for the photorespiration is the **glycolate**. The process of photorespiration takes place in peroxisomes.

360 (d)

Non-cyclic phosphorylation occurs in the membrane or lamellae of grana. Because membrane or lamellae of grana have both photosystem (PS-I and PS-II) and in non-cyclic phosphorylation both PS-I and PS-II participates

361 (b)

**Sugarcane** is a  $C_4$ - plant, which shows high efficiency of carbon dioxide fixation due to **Hatch and Slack cycle**.

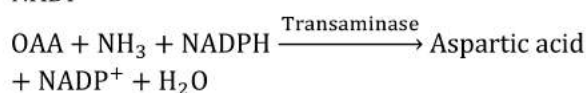
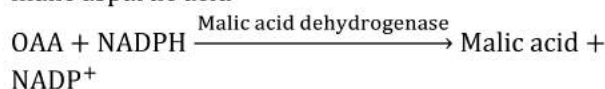
362 (d)

**Carboxylation** (In  $C_3$ -cycle) It is the fixation of  $CO_2$  into a stable organic intermediate. Carboxylation is the most crucial step of the Calvin cycle, where  $CO_2$  is utilised for the carboxylation of RuBP. This reaction is catalysed by the enzyme RuBP carboxylase, which results in the formation of two molecules of 3-PGA. Since, this enzyme also has an oxygenation activity. It would be more correct to call it RuBP **carboxylase-oxygenase** or RuBisCo

363 (a)

Mesophyll cell.

After the fixing of  $CO_2$  to Oxaloacetic Acid (OAA) in  $C_4$  cycle, the oxaloacetic acid changes into the malic aspartic acid



Both of these reactions occur in mesophyll cell

364 (a)

Photorespiration takes place only in  $C_3$ -plants.

365 (b)

90% photosynthesis ( $CO_2$  assimilation) in the world is done by algae (photoplanktons).

366 (c)

In  $C_4$ -plants, agranal chloroplast is present in bundle sheath cells, *e.g.*, sugarcane leaf.

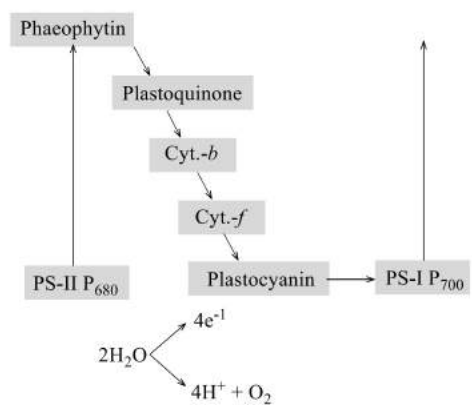
367 (b)

Aldolase enzyme is found in chloroplast.

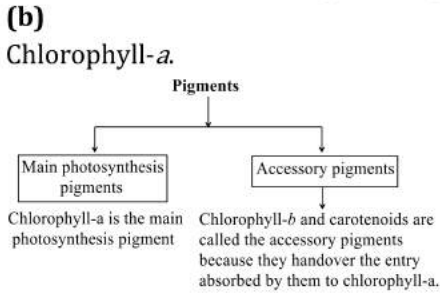
368 (d)

**Emerson and Arnold** (1932) established light and dark phases in photosynthesis with the help of flashing light and Emerson concluded two distinct photochemical process in light reaction of photosynthesis.

- 369 (a) For every  $CO_2$  molecule entering the Calvin cycle (the reduction and regeneration steps), three molecules of ATP and two molecules of  $NADPH+H^+$  are required.
- 370 (a) In Calvin cycle for every carbon dioxide molecule, 3 molecules of ATP and 2 NADPH are required. To make one molecule of glucose 6 turns of the cycle are required. Thus, 18 ATP and 12 NADPH molecules will be required to make one molecule of glucose through Calvin cycle.
- 371 (b)  $C_3$ -pathway.  
Plants that are adapted to dry tropical regions generally have the  $C_4$  pathway. Though these plants have the  $C_4$ -oxaloacetic acid as the first  $CO_2$  fixation product they use the  $C_3$  pathway or the Calvin cycle as the main biosynthetic pathway
- 372 (d)  $C_3$  and  $C_4$ -cycle are the two parts of biosynthetic phase of photosynthesis in  $C_4$ -plant but in  $C_3$ -plant, only  $C_3$  cycle occurs. The enzyme in these two cycles are present in chloroplast not in Golgi bodies
- 373 (c) Photosynthetically Active Radiation (PAR) is 400-700 nm.
- 374 (c)  $C_4$  Plants have 'Kranz type' anatomy. Vascular bundles are surrounded by bundle sheath cells. The chloroplasts are dimorphic. The cells of bundle sheath have very large chloroplasts. They lack grana and contain starch grains. They are centripetally arranged white mesophyll cells have small and granal chloroplast.
- 375 (b) Photorespiration takes place in the photosynthetic cells, eg, green parts of plant in the presence of light.
- 376 (b) In the given schematic diagram, D is representing plastocyanin.



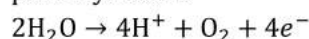
- 377 (a) Photochemical reaction is also known as light reaction because it takes place in the presence of light in the grana portion of chloroplast. In this reaction, photolysis of water takes place, which generates ATP and NADPH
- 378 (a) Non-cyclic photophosphorylation includes both photo system II and I. The process requires an external electron donor. The electrons released during photolysis of water are picked up by photocentre of PS-II called  $P_{680}$ . The flow of electrons is unidirectional. Electrons are not cycled back and are used in the reduction of NADP to  $NADPH_2$ . In this, high energy electrons released from ' $P_{680}$ ' do not return to ' $P_{680}$ ' but pass through phaeophytin, plastoquinone, cytochrome- $b_6 - f$  complex, plastocyanin and then enter  $P_{700}$ . In transfer of electrons from PQ to Cytochrome- $b_6 - f$  complex, ATP is synthesised.
- 379 (a) RuBisCo is the most abundant protein of the biological world. It constitutes 16% of the chloroplast proteins. Rubisco is located on the outer surface of thylakoid membrane
- 380 (d) The chlorophylls are basically chelate salts of magnesium (Mg).
- 381 (a) Ammonia is released from photorespiration.
- 382 (b) Chlorophyll-*a*.



- 383 (c)

Formation of ATP in mitochondria is called oxidative phosphorylation.

The electrons that were moved from photosystem II must be replaced. This is achieved by electrons available due to splitting of water. The splitting of water is associated with the PS-II. Water is split into  $H^+$ ,  $O$  and electrons. This creates oxygen, one of the net products of photosynthesis. The electrons that are needed to replace those removed from photosystem-I are provided by photosystem-II



384 (b)

**Raphids** are needle-like long slender **calcium oxalate** crystals usually lying parallel to each other in a bundle, which is sometimes found in a special sac-like cell. Raphids are commonly found in *Alocasia*, *Colocasia*, *Pistia*, etc.

385 (c)

Nucleus/core of chlorophyll contains magnesium. The chlorophylls are basically chelate salts of magnesium (Mg)

386 (d)

During the dark reaction, the starch (carbohydrates) synthesis takes place. The starch is the polymers of glucose having the formula  $(C_5H_{10}O_5)_n$

387 (b)

In  $C_3$ -plants, carbon dioxide combines with RuBP to form phosphoglyceric acid, on the other hand in  $C_4$ -plants, carbon dioxide is first picked up by phosphoenol pyruvate (PEP) to form oxaloacetic acid.

388 (c)

Development of proton gradient across the membrane.

During the cyclic phosphorylation, the electrons does not pass to the  $NADP^+$  but cycled back to PS-I through electron transport chain. This cyclic flow hence, results only in the synthesis of ATP but no of  $NADPH + H^+$ . Cyclic photophosphorylation occurs when only light of wavelength beyond 700 nm is available for excitation

389 (b)

In photorespiration, the RuBP instead of being converted to two molecules of PGA binds with  $O_2$  to form one molecules of PGA and phosphoglycolate. In the phosphorespiratory pathway, there is neither synthesis of sugars, nor

of ATP. In this pathway there is no synthesis of ATP or NADPH. Therefore, it is a wasteful process.

390 (c)

Maximum photosynthetic rate has been observed in the full spectrum. Regarding the effect of the different wavelengths, maximum photosynthesis occurs in **red** light (660 nm) second maximum in **blue** (440 nm) and minimum in **green**.

391 (b)

Chloroplasts are found in the mesophyll cells of the leaves. Leaves have a maximum number of chloroplasts

392 (d)

New plastids arise from proplastids by a fission-like process.

393 (c)

Photosynthesis is an anabolic process of manufacturing of organic compounds. It is characterized by reduction of  $CO_2$  and oxidation of water. It decreases the concentration of  $CO_2$  in atmosphere but increases the concentration of  $O_2$ .

394 (d)

RuBisCo is present in chloroplast

395 (d)

The leaves of  $C_4$ -plants have Kranz anatomy. In the leaf, vascular bundle is surrounded by bundle sheath and mesophyll cells. The bundle sheath consists of thick walled cylindrical cell. The chloroplasts of bundle sheath are larger than mesophyll cells. Most of the PEP carboxylase occurs in mesophyll cells, while most of ribulose 1-5 diphosphate carboxylase and malic enzyme in bundle sheath cells.

396 (a)

In  $C_3$ -plants, photorespiration takes place but this pathway is absent in  $C_4$ -plants

397 (a)

ATPase has two parts- $F_0$  and  $F_1$ .  $F_0$  part has channels through, which the diffusion of protons takes place

398 (b)

**The Calvin cycle proceeds in three stages** (1) carboxylation, during which  $CO_2$  combines with ribulose 1, 5-bisphosphate; (2) reduction, during which carbohydrate are formed at the expense of the photochemically made ATP and NADPH; and (3) regeneration during,  $CO_2$  acceptor is ribulose 1, 5-bisphosphate is formed again so that the cycle continues. Regeneration of the  $CO_2$  acceptor



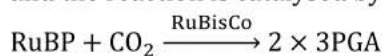
molecule, RuBP is crucial if the cycle is to continue uninterrupted. The regeneration steps require one ATP for phosphorylation to form RuBP

399 (c)

RuBisCo is the most abundant enzyme in the world. It is characterised by the fact that active sites can bind to both CO<sub>2</sub> and O<sub>2</sub>. This binding is competitive. It is the relative concentration of O<sub>2</sub> and CO<sub>2</sub> that determines, which of two (CO<sub>2</sub> and O<sub>2</sub>) will bind to enzyme

400 (b)

In the Calvin cycle, the RuBP combines with the CO<sub>2</sub> to form 2 molecules of 3 phosphoglyceric acid and the reaction is catalysed by RuBisCo



401 (a)

Cyclic phosphorylation operates only by PS-I during cyclic phosphorylation only. ATP formation takes place and recycling of electrons also occurs. Unlike, the non-cyclic phosphorylation, splitting of H<sub>2</sub>O does not take place in the cyclic phosphorylation

402 (c)

The carbon dioxide fixation takes place in the stroma of chloroplasts because it has enzymes essential for fixation of carbon dioxide and synthesis of sugar.

403 (d)

Some differences in C<sub>3</sub> and C<sub>4</sub> plants.

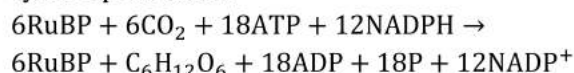
C <sub>3</sub> -plants	C <sub>4</sub> -plants
Algae (Chlorella), sunflower, beans, mustard, etc. Plants have Calvin cycle.	Maize, sorghum, sugarcane and other graminaceous plants. Plants have Hatch and Slack cycle.
The first stable product of photosynthesis is 3-C compound, phosphoglyceric acid (PGA).	The first stable product is 4-C compound, oxaloacetic acid or malic acid in succulents.
There is only one carbon dioxide acceptor, e.g., ribulose 1-5, diphosphate. Kranz anatomy is absent.	There are two carbon dioxide acceptor, e.g., phosphoenol pyruvic acid and RuDP.
The optimum temperature lies between 10-25°C. Photorespiration occurs, which	The leaves have Kranz anatomy. The optimum temp. lies between 30-45°C. No photorespiration.
	Bundle sheath chloroplast lack photosystem-II, therefore, depends

reduces the photosynthetic yield. Chloroplast have PS-I and PS-II

upon mesophyll for supply of NADPH + H<sup>+</sup>

404 (c)

In Calvin cycle, 18 molecules of ATP are used in carbon fixation. The overall reaction of Calvin cycle represents as



405 (c)

Stroma side of membrane

406 (b)

Cyclic Photophosphorylation involves only PS-I and in this electron expelled by excited photocentre is returned to it after passing over a chain of electron carriers. Two molecules of ATP are synthesized in this process.

407 (a)

The site for photorespiration is chloroplast. Peroxisome and mitochondria are required for completion of the process. It is a cyclic process. Glycolate is formed in chloroplast, which usually passes into peroxisome of the mesophyll cell where it is oxidised to glyoxylate. Glyoxylate is aminated and gives rise to amino acid glycine that enters to mitochondrion.

408 (b)

For the ease of understanding Calvin cycle can be described under three stages

(i) **Carboxylation** is the fixation of CO<sub>2</sub> into stable organic intermediate

(ii) **Reduction** is a series of reactions that lead to the formation of glucose

(iii) **Regeneration** of CO<sub>2</sub> acceptor molecule, RuBP is main, part of this stage

409 (a)

In 780 nm of wavelength, photosystem-I is inactive. In photo system-I, the photocentre is special chlorophyll-a molecule called P<sub>700</sub>.

410 (c)

Bacterial photosynthesis involves only **photosystem-I**(PS-I) and cyclic photophosphorylation. It is not connected with photolysis of water, therefore, oxygen is not evolved. This synthesizes only ATP.

411 (b)

In C<sub>4</sub>-plants, fixation of carbon dioxide occurs in mesophyll cells. The primary acceptor of carbon dioxide is phosphoenol pyruvate (PEP). It combines with carbon dioxide in the presence of

PEP carboxylase to form oxaloacetate or oxaloacetic acid (OAA).

412 (d)

In photosystem-I, the primary electron acceptor is probably a Fe-S protein. The reduced primary acceptor transfers the electrons to secondary electrons acceptor (most probably ferradoxin).

413 (b)

**Reduction** These are series of reactions that lead to the formation of glucose. The steps involved are: utilisation of 2 molecules of ATP for phosphorylation and two molecules of NADPH for the reduction per CO<sub>2</sub> molecule fixed. The fixation of six molecules of CO<sub>2</sub>, 6 turns of the cycle the required for the removal of one molecule of glucose from the pathway

414 (c)

A-Released, B-Lumen, C-ATPase

415 (b)

Photosynthesis and respiration are similar because both organelles make ATP and are explained by chemiosmotic theory. During the formation of ATP, both organelle uses Electrons Transport Channels (ETC)

416 (d)

Cyclic Photophosphorylation is performed by PS-I only. It involves a cyclic electron flow, in which the photoexcited electrons from PS-I are occasionally shunted back to chlorophyll via the electron transport chain. This cyclic electron flow supplements the supply of ATP but produces no NADPH. Non-cyclic Photophosphorylation involves both PS-I and PS-II. Splitting of water, release of oxygen and production of NADPH takes place during it.

417 (c)

Quantum yield of photosynthesis is carbohydrate or dry mass, formed by plant by using carbon dioxide from air. It is about 12% in C<sub>3</sub> -plants.

419 (a)

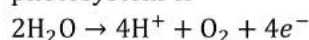
The primary CO<sub>2</sub> fixation product in C<sub>4</sub> cycle is oxaloacetic acid (OAA) in the mesophyll cells. It then from the other 4-carbon compounds like

malic acid or aspartic acid in the mesophyll cells itself, which are transported to the bundle sheath cells.

420 (b)

ATP synthesised by chloroplast and mitochondria in the cell.

The electrons that were moved from photosystem II must be replaced. This is achieved by electrons available due to splitting of water. The splitting of water is associated with the PS-II. Water is split into H<sup>+</sup>, O and electrons. This creates oxygen, one of the net products of photosynthesis. The electrons that are needed to replace those removed from photosystem-I are provided by photosystem-II

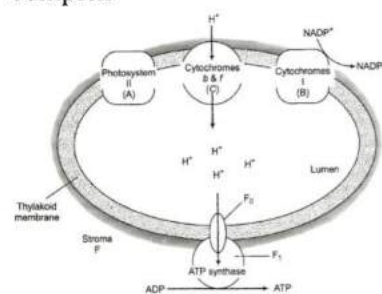


421 (b)

In C<sub>4</sub>-plants, initial fixation of CO<sub>2</sub> occurs in **mesophyll cells**. The primary acceptor of CO<sub>2</sub> is phosphoenol pyruvate (PEP). CO<sub>2</sub> is again fixed inside bundle sheath cells through Calvin cycle. The pyruvate is sent back to mesophyll cells where it is changed to phosphoenol pyruvate (PEP).

422 (d)

Proton gradient develops inside the lumen, due to the accumulation of protons by the transportation of electrons through electron transport system. This leads to the formation of ATP by ATPase complex



423 (a)

3-phosphoglyceric acid (3-PGA) is the first stable product of Calvin-Benson cycle or C<sub>3</sub>-cycle or **carbon-reduction cycle**.