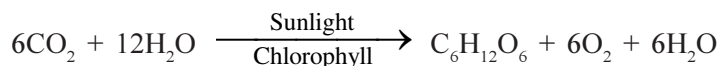


Plants use sunlight (Photon), (H₂O) and (CO₂) to convert light Energy into chemical Energy by chlorophyll. This process is known as photosynthesis.

Chemical equation :



Necessary factors for photoynthesis :

- Light
- Chlorophyll
- Water (H₂O)
- Carbon Dioxide (CO₂) (0.03 % in the atmosphere)

Photosynthetic Organisms :

- Different types of algae (Blue green algae, Brown algae, Red algae, Green algae).
- Bryophytes, Pteridophytes, Gymnosperms, Angiosperms.
- Some bacteria.

(Note : Fungi is not able to perform photosynthesis due to lack of chlorophyll.)

Advantages of Photosynthesis :

- Main products of photosynthesis are starch and sucrose.
- (O₂) is byproduct which is used by organisms for respiration.

(1) What is produced as byproduct of photosynthesis ?

- (A) Oxygen (B) Nitrogen (C) Carbon dioxide (D) Sulphur dioxide

(2) Which type of energy can be used by all organisms ?

- (A) Light energy (B) Chemical energy (C) Heat energy (D) Water potential

(3) Which of the following type of reaction photosynthesis is ?

- (A) Anabolic, Endothermic, Reduction (B) Anabolic, Endothermic, Oxidation
(C) Catabolic, Exothermic, Oxidation (D) Catabolic, Endothermic, Reduction

Answers : (1-A), (2-B), (3-A)

History of Photosynthesis :

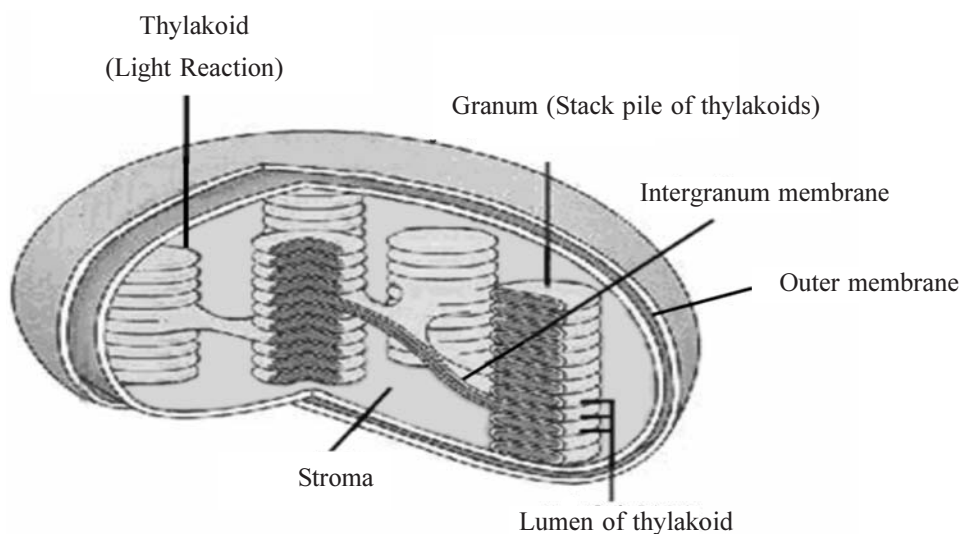
No.	Name of Scientist	Contribution
1.	Joseph Priestly (1733-1804)	Plants obtain CO ₂ from atmosphere and release O ₂ .
2.	Ingenhouse (1730-1799)	In bright sunlight, small bubbles were formed around the green parts of the plant.
3.	Julius Von Sachs (1854)	Green substance (chlorophyll) in plants is located in special bodies (chloroplast) of plant cell. This green substances produces glucose which is usually stored in the form of starch.
4.	Robert Hill	O ₂ released into atmosphere comes from water during photosynthesis. He gave equation : $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$
5.	Cornelius Van Niel (1897-1985)	Photosynthesis is essentially a light dependent reaction in which hydrogen from a suitable oxidisable compound reduces CO ₂ to carbohydrates. He gave equation as follows : $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$

- (4) Which scientist showed that plants releases O₂ and obtain CO₂ ?
 (A) Jan Ingenhousze (B) Julius Von Sachs (C) Joseph Priestly (D) Van Niel
- (5) Which modified equation is given by Hill ?
 (A) $6\text{CO}_2 + 10\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{10}\text{O}_6 + 5\text{H}_2\text{O} + 6\text{O}_2$
 (B) $5\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 5\text{H}_2\text{O} + 6\text{O}_2$
 (C) $4\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$
 (D) $6\text{CO}_2 + 12\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2$
- (6) Which scientist showed that Light is necessary for study of photosynthesis in blue green algae ?
 (A) Cornelius Van Niel (B) Jan Ingenhousze (C) Julius Von Sach (D) Robert Hill
- (7) Which scientist demonstrated that O₂ is liberated only by chlorophyll containing organs of the plant in presence of O₂ ?
 (A) Priestly (B) Niel (C) Ingenhousze (D) Helmont
- (8) Which type of reaction photosynthesis is ?
 (A) Anabolic (B) Catabolic (C) Metabolic (D) All of the above

Answers : (4-C), (5-D), (6-A), (7-C), (8-A)

Structure of Chloroplast : (Site for photosynthesis)

- The process of photosynthesis takes place in green organs of the plants.



Structure

Chloroplast has main two parts :

(A) Grana (Membranous)

(B) Stroma.

Grana :

- Each Granum is made up of flat, lamellar structure called thylakoid.
- These thylakoids contain chlorophyll pigments.

These are the main pigments of chloroplast :

Chlorophyll-a	(C ₅₅ H ₇₂ O ₅ N ₄ Mg)	- Green coloured
Chlorophyll-b	(C ₅₅ H ₇₀ O ₆ N ₄ Mg)	- Green coloured
Xanthophyll	(C ₄₀ H ₅₆ O ₂)	- Yellow coloured
Carotenoids		- Yellow to Orange coloured

- Amount of substances is different in all plants.

Stroma (Chlorenchyma) :

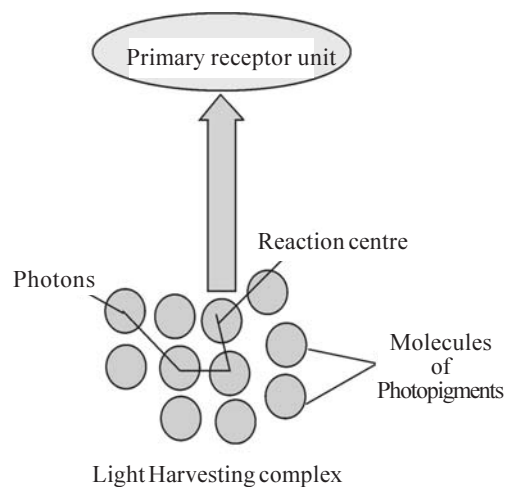
- Enzymes necessary for Calvin cycle are present in Stroma.

Functions :

- Light reaction takes place in Grana.
- In Light reaction ATP and NADP are produced.
- Second phase of photosynthesis is dark reaction which occurs in Stroma, Enzymes become activated, So CO₂ and H₂O combine to form C₆H₁₂O₆.
- Dark reaction is dependent on the product of light reaction.

Photopigment System :

- We can identify different pigments by Chromatography.
- Pigments are classified on the basis of colour.
- These photopigments absorb light at specific wavelength and obtain energy from them.
- Chlorophyll is a main reactant of this process.
- Other pigments work as accessory pigment.
- The photosynthetic pigments at reaction centre are stimulated by specific wavelength. On the basis of this they are divided into two.



- These light harvesting complexes are known as PS-I and PS-II. (Ps = Photopigment system)

No.	Features	PS-I	PS-II
(1)	Reaction centre	PS-I is also known as P 700.	PS-II is also known as P 680.
(2)	Process	Participates in cyclic and noncyclic photophosphorylation.	Participates only in noncyclic photophosphorylation.
(3)	e^- gain	Picks up e^- released by PS-II.	Picks up e^- obtained by photolysis of water.
(4)	Oxygen	Does not show presence of Oxygen.	During photolysis of water O_2 is produced.
(5)	Wavelength	It gets stimulated at 700 nm wavelength.	System is stimulated at 680 nm wavelength.

(9) Number of piles of flat lamellar thylakoids is known as

- (A) Grana (B) Stroma (C) Granum (D) Lamellae

- (10) In the process of photosynthesis
 (A) O_2 is liberated and $NADPH_2$ is formed.
 (B) Production of ATP and $NADPH_2$ occurs.
 (C) Production of ATP and $NADPH_2$ occurs and O_2 is released.
 (D) Fixation of CO_2 occurs.
- (11) Which of the following is the place for chlorophyll ?
 (A) In Stroma (B) On the surface of chloroplast
 (C) In Grana (D) Overall chloroplast
- (12) In which part of the leaf process of photosynthesis occurs ?
 (A) Vascular bundle (B) Mesophyll tissue (C) Upper epidermis (D) Lower epidermis
- (13) Where does the chloroplast present in the cell ?
 (A) In the centre (B) Near to nucleus (C) Scattered (D) At periphery
- (14) The intense light oxidise chlorophyll and causes damage to the plant. It is known as
 (A) Photorespiration (B) Photooxidation (C) Photolysis (D) Photoreduction
- (15) What is LHC ?
 (A) Lower Hard Complex (B) Light High Complex
 (C) Light Harvesting Complex (D) Light Heavy Complex
- (16) Which of the following group is accessory photosynthetic pigment ?
 (A) Chlorophyll-b, Xanthophyll, Chlorophylla (B) Chlorophyll-b, Xanthophyll, Carotenoides
 (C) Chlorophyll-b, Carotenoids, Chlorophyll-a (D) Chlorophyll-b, Fibrin, Xanthophyll
- (17) Which pigments are yellow to Orange ?
 (A) Chlorophyll-a (B) Xanthophyll (C) Carotenoids (D) Chlorophyll-b
- (18) How many Light Harvesting complexes are formed, by photosynthetic pigments ?
 (A) Two (B) Three (C) Four (D) Five
- (19) How many chlorophyll pigments are present in each pigment system ?
 (A) 300 to 400 (B) 400 to 500 (C) 350 to 800 (D) 250 to 400
- (20) Which system is more sensitive to intense wavelength of light in photo pigment system ?
 (A) PS-I (B) PS-II
 (C) Splitting of water molecule by light (D) Light harvesting system
- (21) What is known as PS-II ?
 (A) P_{700} (B) P_{680} (C) LHC-I (D) RHC-I

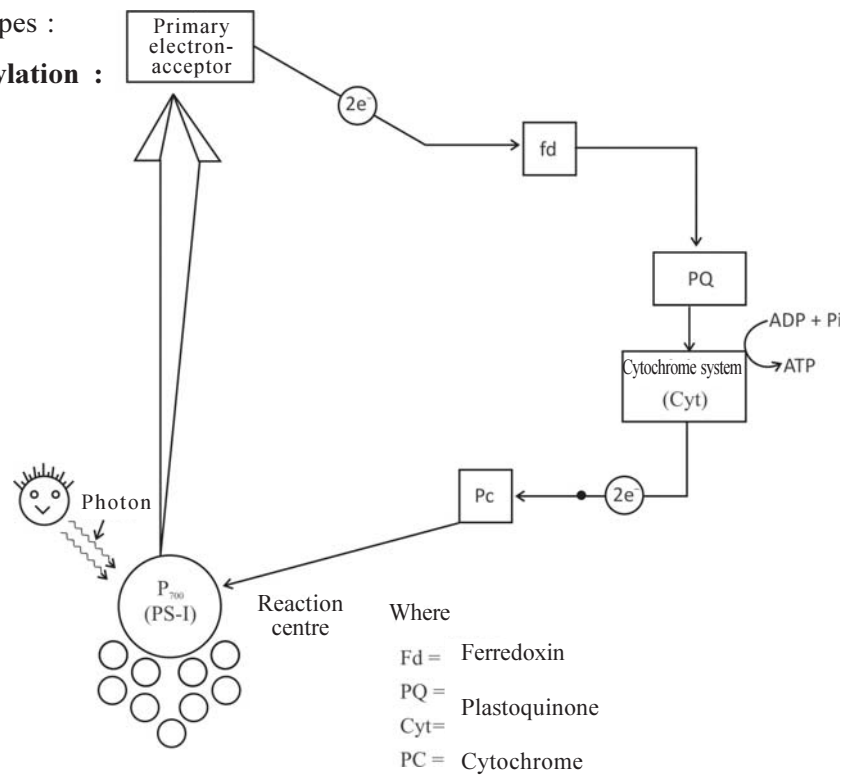
Answers : (9-A), (10-C), (11-C), (12-B), (13-D), (14-B), (15-C), (16-B), (17-C), (18-A), (19-D), (20-A), (21-B)

Phases of Photosynthesis :

(A) Light Reaction :

- There are mainly two types :

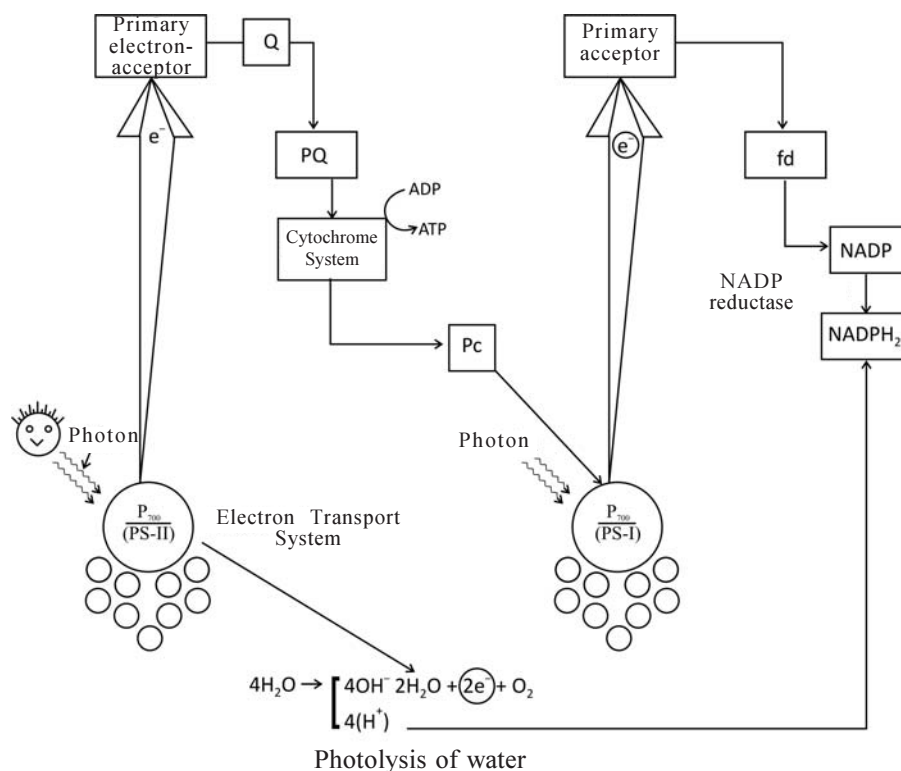
(a) Cyclic Photophosphorylation :



Cyclic Photophosphorylation Reaction :

In cyclic photophosphorylation e^- transporters Ferredoxin (Fd) $\rightarrow$ Plastoquinone (PQ) $\rightarrow$ Cytochrome system $\rightarrow$ Plastocyanin (Pc) sends electron to its main source of PS-I.

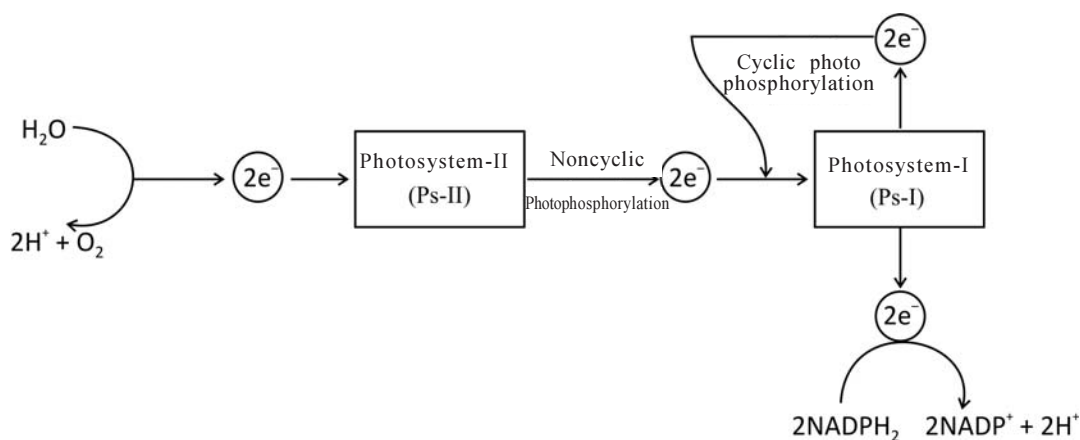
(b) Noncyclic Photophosphorylation :



From PS-II to PS-I :

Electron passes Quinone → Plastoquinone → Cytochrome system → Plastocyanin → PS-I.

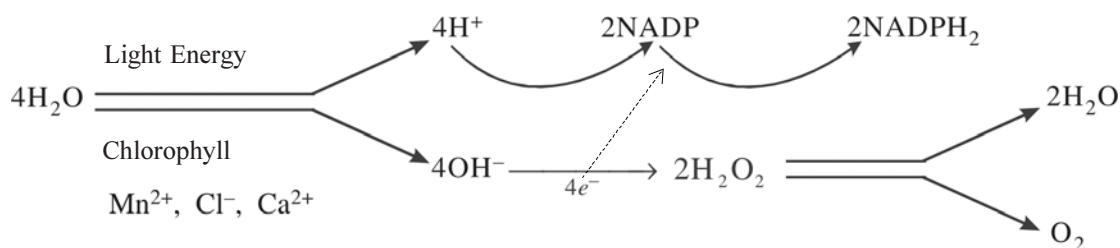
Here in PS-I Ferredoxin accepts the electron and next utilized for reduction of NADP.

Summary of Cyclic and Noncyclic Photophosphorylation :

No.	Features	Cyclic Photo Phosphorylation	Non Cyclic Photophosphorylation
1.	Production	Produces ATP.	Produces ATP and NADPH_2 .
2.	Oxygen	Oxygen does not take part.	Oxygen is produced by photolysis of water.
3.	Photopigment system	Only PS-I participates.	Participation of PS-I & PS-II both.
4.	e^- Transportation	Electrons released from PS-I goes back to the same source. No e^- from any other molecules enter in the system.	Electrons released from PS-I and PS-II does not revert to the main source. Outer e^- released from photolysis of water enter in the system.
5.	Efficiency	Usually occurs during anaerobic condition, less light intensity and less CO_2 concentration.	Usually occurs during aerobic condition, high light intensity and high CO_2 concentration.
6.	Process	Usually occurs in bacteria like organisms.	Usually occurs in CO_2 fixative plants and another photosynthetic organisms.

(c) **Photolysis of Water :**

The splitting of water molecule using energy of light is known as photolysis of water. The entire process can be presented as under :



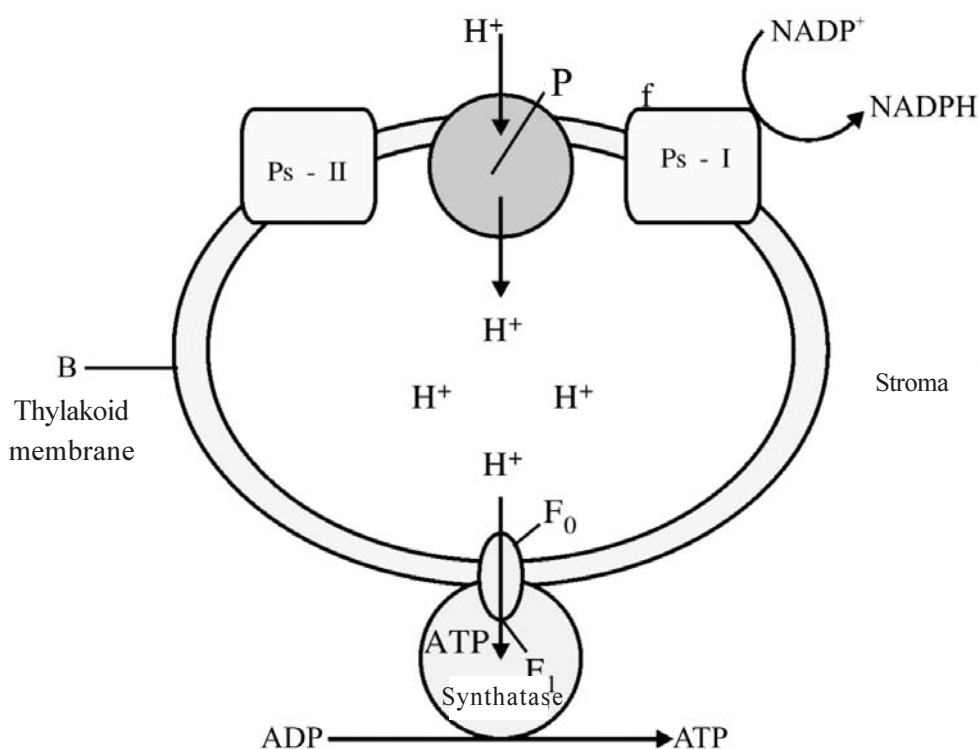
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- (22) Which of the following accepts electron at last that released by photolysis of water ?
(A) PS-I (B) PS-II (C) OAA (D) NADP
- (23) How many water molecules split at a time in light reaction of photosynthesis ?
(A) 1 (B) 4 (C) 2 (D) 6
- (24) Which are the essential ions for photolysis of water ?
(A) Mn^{+2} , Cu^{+2} , Cl^- (B) Na^+ , Mg^{+2} , Cl^- (C) Mn^{+2} , Ca^{+2} , Cl^- (D) Mn^{+2} , Fe^{+2} , Cl^-
- (25) Which pigment is associated with oxidation of water ?
(A) PS-I (B) PS-II (C) Phycobilism (D) Carotenoids
- (26) What is the product formed by 4OH^- at the end of photolysis of water ?
(A) $2\text{H}_2\text{O}$ (B) 2NADPH_2 (C) O_2 (D) (A) and (B) both
- (27) What is primary acceptor of $4e^-$ released by PS-I in cyclic photophosphorylation ?
(A) Cytochrome (B) Electron transport system
(C) Electron acceptor (D) PS-II
- (28) Which of the following process occurs in cyclic photophosphorylation ?
(A) Reduction of NADP (B) Photophosphorylation
(C) Photolysis (D) Production of O_2
- (29) How many photons are accepted by PS-I for initiation of cyclic photophosphorylation in light reaction of photosynthesis ?
(A) One (B) Two (C) Three (D) Four
- (30) Where does photophosphorylation occur ?
(A) In PS-I (B) In PS-II (C) In (A) and (B) both (D) In thylakoid
- (31) What is Phosphorylation ?
(A) Production of ATP from ADP in presence of light
(B) Production of ADP from ATP in presence of light.
(C) Oxidation of NADPH_2 in presence of light.
(D) Reduction of NADPH_2 in presence of light.
- (32) What happens during electron transportation ?
(A) Energy is released (B) Energy is utilized
(C) Reduction (D) Energy is stored
-

- (33) The process associated with cyclic photophosphorylation
 (A) O_2 is produced (B) Phosphorylation occurs
 (C) Reduction of $NADPH_2$ (D) Photolysis of water
- (34) Sequence of electron transport released from cyclic photophosphorylation
 (A) $Fd \rightarrow Cyt \rightarrow Pc \rightarrow PQ$ (B) $Fd \rightarrow PQ \rightarrow Cyt \rightarrow Pc$
 (C) $PQ \rightarrow Q \rightarrow Cyt \rightarrow Pc$ (D) $Q \rightarrow PQ \rightarrow Cyt \rightarrow Pc$
- (35) Which electron transporter is not present in cyclic photophosphorylation ?
 (A) Fd (B) Q (C) PQ (D) Cyt
- (36) What is photon ?
 (A) Electron transporter (B) Molecules of chlorophyll
 (C) Molecule form of light (D) Wave form of light
- (37) Which of the following molecule works as a reaction centre in noncyclic photophosphorylation ?
 (A) Chlorophyll a of PS-I (B) Chlorophyll a of PS-II
 (C) LHC (D) (A) and (B) both
- (38) Who accepts $4e^-$ released by PS-I at last in Noncyclic photophosphorylation ?
 (A) PS-I (B) PS-II (C) NADP (D) RuBP
- (39) Who accepts $4e^-$ released by PS-II at last in Noncyclic photophosphorylation ?
 (A) PS-I (B) NADP (C) RuBP (D) H_2O
- (40) From which photopigment system e^- is obtained for reduction of NADP during Noncyclic photophosphorylation ?
 (A) PS-I (B) PS-II
 (C) From PS-I and PS-II both (D) None of the above
- (41) How many ATP molecules are formed during noncyclic photophosphorylation ?
 (A) 2 ATP (B) 1 ATP (C) 3 ATP (D) 6 ATP
- (42) Which of the following process occurs first in photosynthesis ?
 (A) Production of O_2 (B) Noncyclic photophosphorylation
 (C) Photolysis of water (D) Reduction of NADP
- (43) $4H^+ + 2NADP \xrightarrow{4e^-} 2NADPH_2$. From where the $4e^-$ are obtained in the given process ?
 (A) PS-I (B) PS-II (C) Photon (D) H_2O
- (44) Which of the following electron transporters are associated with cyclic and Noncyclic photophosphorylation ?
 (A) PQ (B) PC (C) Cyt (D) All of the above
- (45) Which of the following accepts e^- released from PS-II ?
 (A) PQ (B) Cyt (C) Q (D) Pc

- (46) After removal of thylakoid, if we put leaf in CO_2 and H_2O containing medium in presence of sunlight, Hexose is not the Final product, because
- (A) Molecules which obtains light are absent. (B) Photosystem PS-I and PS-II are not present.
- (C) Enzymes which fixes CO_2 are absent. (D) CO_2 fixation does not occur in presence of light.

Answers : (22-D), (23-B), (24-C), (25-B), (26-D), (27-C), (28-B), (29-D), (30-D), (31-A), (32-A), (33-B), (34-B), (35-B), (36-C), (37-D), (38-C), (39-A), (40-A), (41-B), (42-C), (43-A), (44-D), (45-C), (46-C)

Chemiosmosis :



ATP synthesis through chemiosmosis

- The chemiosmotic hypothesis has been put forward to understand synthesis of ATP in chloroplast during photosynthesis.
- ATP synthesis is dependent on concentration gradient generated across thylakoid membrane.
- Due to splitting of water molecule protons (hydrogen ions) are liberated, which are accumulated in lumen of thylakoid.
- Outside the thylakoid membrane that is in Stroma - Protons are used to reduce NADP^+ . So number of protons decreases in stroma and number increases in lumen of thylakoid.
- So, concentration gradient is created across the thylakoid membrane.

Function of Proton Gradient :

- Enzyme ATPase has two components : F_0 and F_1 .
- F_0 is embedded in the membrane which, works as transmembrane channel.
- F_1 which protrudes on the outer surface of thylakoid membrane facing stroma.
- Abundant energy is produced due to breakage of concentration gradient.
- This conformational change in F_1 particle ATPase makes the enzyme to synthesize several molecules of energy packed ATP. $ADP + Pi \rightarrow ATP$.

Use of ATP :

The ATP produced will be used immediately along with NADPH in the biosynthetic phase taking place in stroma.

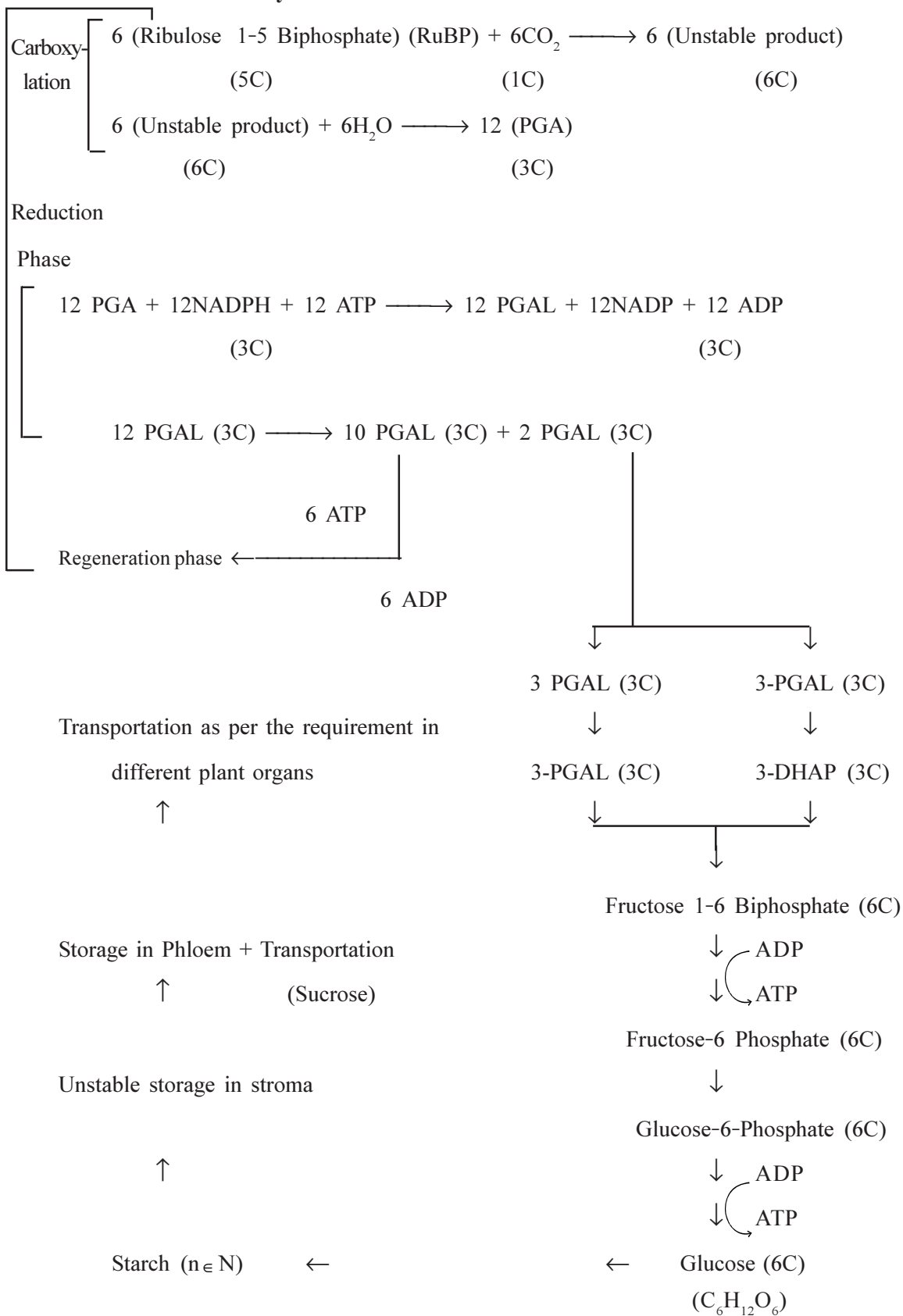
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- (47) By splitting of which molecule H^+ formation occurs in thylakoid ?
(A) CO_2 (B) NAD (C) H_2O (D) NADP
- (48) Which molecule is reduced in stroma outside the thylakoid membrane according to chemiosmotic hypothesis ?
(A) CO_2 (B) NAD (C) H_2O (D) NADP
- (49) What we can understand by chemiosmotic hypothesis ?
(A) Splitting of H_2O (B) Synthesis of ATP in chloroplast
(C) Fixation of CO_2 (D) Reduction of NADP
- (50) What is responsible for change in F_1 component of ATPase ?
(A) Presence of proton acceptor $NADP^+$ (B) Noncyclic transportation of electrons
(C) Energy released by proton gradient (D) Enzymes of F_0 component
- (51) What is the cause for creation of proton gradient across the Thylakoid membrane ?
(A) Increase in number of protons in thylakoid.
(B) Decrease in number of protons in stroma.
(C) Decrease in pH in cavity of thylakoid.
(D) All of the above

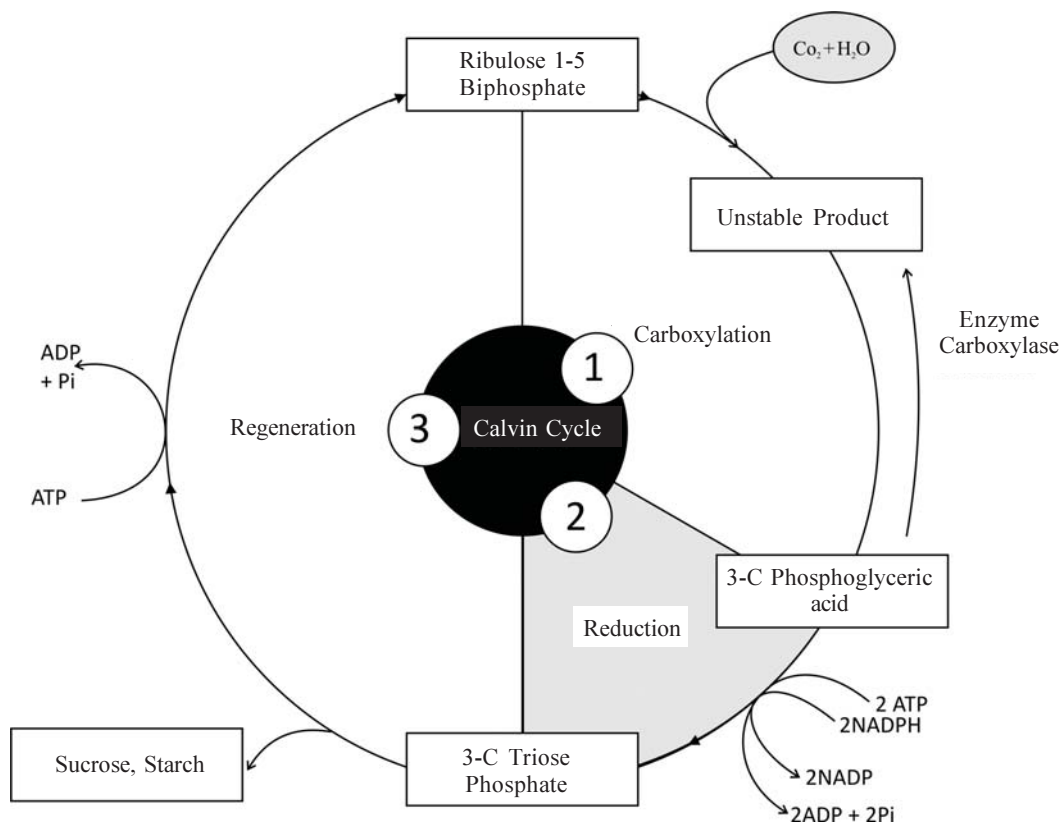
Answers : (47-C), (48-D), (49-B), (50-C), (51-D)

(B) Biosynthetic Phase : CO_2 fixation, Calvin cycle, C_3 path, Dark reaction, Reduction of RuBP.

- This process occurs in stroma of thylakoid.
- Light is not necessary for this process.
- H_2O and CO_2 combines to form sugar.
- Malvin Calvin by using radioactive C^{14} in algal photosynthesis described this process.
- So, this process is known as Calvin cycle.
- They got Nobel Prize in 1961.
- Steps necessary for this process are shown as under :

Main Phases of Biosynthetic Phase :





- (52) In dark reaction of photosynthesis
- (A) 3C compound is formed by splitting of 6C sugar.
 (B) Photolysis of water occurs.
 (C) Molecules of chloroplast are stimulated.
 (D) Carbonic compounds are formed by reduction of CO_2 .
- (53) Which radioactive isotope is used to explain C_3 - path ?
- (A) C^{12} (B) C^{14} (C) C^{13} (D) C^{16}
- (54) Which enzyme is responsible to join CO_2 and RuBP ?
- (A) NADP reductase (B) ATPase
 (C) RuBP Carboxylase (D) Cytochrome Oxidase
- (55) Which sugar is used in first step of Biosynthesis ?
- (A) $\text{C}_6\text{H}_{12}\text{O}_6$ (B) RuBP (C) DHAP (D) PGAL
- (56) Which type of sugar is used in Calvin cycle ?
- (A) Aldotriose (B) Ketotriose (C) Aldopentose (D) Ketopentose
- (57) How many ATP and NADPH_2 are required for fixation of one CO_2 molecule ?
- (A) $3\text{ATP} + 1\text{NADPH}_2$ (B) $2\text{ATP} + 2\text{NADPH}_2$
 (C) $3\text{ATP} + 2\text{NADPH}_2$ (D) $3\text{ATP} + 3\text{NADPH}_2$
- (58) From which molecule 3 - Carbon of phosphoglyceric acid are obtained during carbon fixation ?
- (A) $\text{PEP} + \text{CO}_2$ (B) CO_2 (C) RuBP (D) $\text{RuBP} + \text{CO}_2$

- (59) Calvin cycle starts with
 (A) PGA (B) RuBP (C) OAA (D) PGAL
- (60) How many ATP and NADPH are necessary for production of one glucose ?
 (A) 12, 20 (B) 6, 3 (C) 18, 12 (D) 10, 20
- (61) What is the product of carboxylation in stroma of chloroplast ?
 (A) PGA (B) PGAL (C) DHAP (D) RuBP
- (62) What is the product formed by removal of 'O' from PGA ?
 (A) PGAL (B) DHAP (C) RuBP (D) OAA
- (63) How many molecules of 3-PGAL are necessary for regeneration of RubP ?
 (A) 12 (B) 8 (C) 10 (D) 6

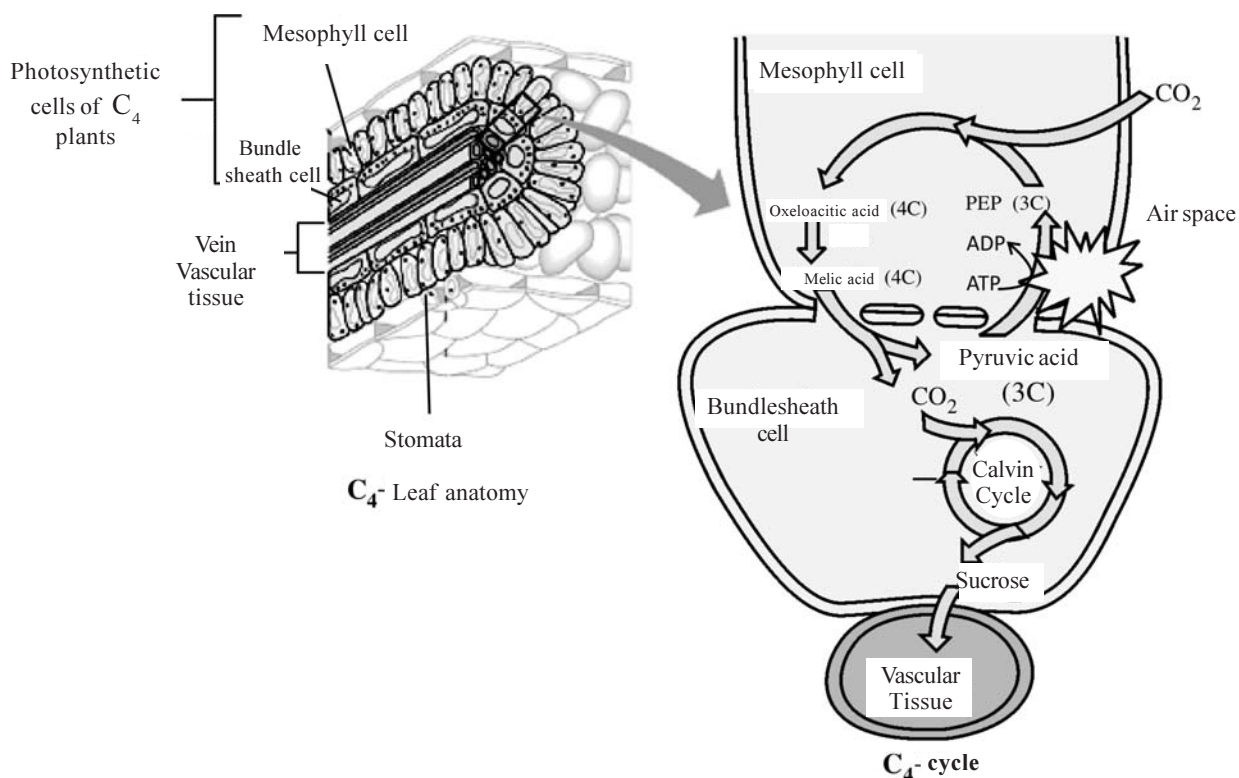
Answers : (52-D), (53-B), (54-C), (55-B), (56-D), (57-C), (58-D), (59-B), (60-C), (61-B), (62-A), (63-C)

C₄ – Path (Hatch Slack Pathway)

- C₄ pathway is generally observed in the monocot plants which grow in the tropical regions.
- It is very clearly observed in the leaves of sugarcane.
- Special type of Kranz anatomy is seen in C₄ pathway.

According to Kranz Anatomy :

Bundle Sheath Cell	Mesophyll Cell
• They do not show grana organization. (Only thylakoids are present.) • C₃-cycle is observed for CO₂ fixation. • This type of arrangement prevents entry of O₂, evolved during light reaction, from entering bundle sheath cells. So, there is no possibility of photorespiration.	• They show grana organization. (Thylakoids are arranged in piles.) • Light reaction occurs and OAA is produced.



Special Characters :

- Due to release of CO_2 in bundle sheath cells, the concentration of CO_2 goes on increasing. As the process of CO_2 fixation occurs in these cells. Also, more food is prepared through biosynthetic fixation.
- As there is no possibility of photorespiration, C_4 is more efficient than C_3 .

Differences between C_3 and C_4 path :

No.	Character	C_3 - Path	C_4 - Path
1.	Type of cell	One (Mesophyll)	Two (Mesophyll) and bundle sheath cell
2.	Kranz Anatomy	Does not occur	Occurs
3.	Chloroplast	With grana	With and Without grana
4.	First CO_2 Acceptor	RuBP	PEP
5.	First Product	PGA (C_3)	Oxalo acetic acid (C_4)
6.	Productivity (Food)	Normal	High

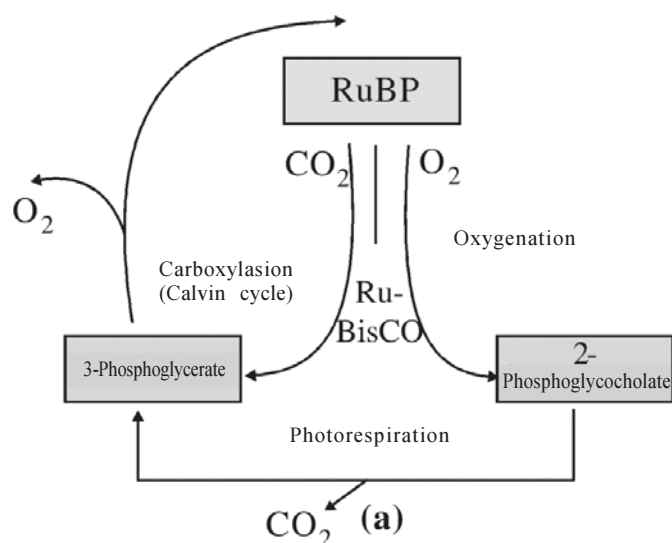
- (64) Which of the following plant shows C_4 path ?
 (A) Sunflower (B) Potato (C) Maize (D) Bignonia
- (65) Which of the following plant utilizes maximum light ?
 (A) Paddy (B) Sugarcane (C) Wheat (D) Sorghum
- (66) How C_4 - cycle is different from C_3 - cycle ?
 (A) Photosynthetic product (B) Number of ATP for production of sugar
 (C) Molecule of CO_2 fixation (D) Photopigments which play role in photosynthesis
- (67) In which part light reaction occurs in C_4 plants ?
 (A) cells of Mesophyll (B) In Bundle sheath cells
 (C) In epidermal cells (D) In phloem
- (68) What is produced by decarboxylation of Malic acid in bundle sheath cells in C_4 plants ?
 (A) PGA (B) PEP (C) PEPA (D) Pyruvic Acid
- (69) How many Calvin cycles are necessary for production of 1 glucose ?
 (A) 2 (B) 3 (C) 4 (D) 6
- (70) First and Second CO_2 acceptor in C_4 path are
 (A) RuBP, PEP (B) PEP, RuBP (C) OAA, PEP (D) PEP, OAA

- (71) What is the number of ATP for production of 1 glucose in C_4 - pathway ?
 (A) 10 (B) 20 (C) 16 (D) 30
- (72) How many times biochemical reactions occurs for production of one glucose molecule in C_4 - path ?
 (A) 2 (B) 4 (C) 6 (D) 8
- (73) By which process Malate is formed from PEP ?
 (A) Carboxylation, Dehydrogenation
 (B) Carboxylation, Hydrogenation
 (C) Decarboxylation, Hydrogenation
 (D) Decarboxylation, Dehydrogenation

Answers : (64-C) (65-B), (66-C), (67-A), (68-D), (69-D), (70-B), (71-D), (72-C), (73-A)

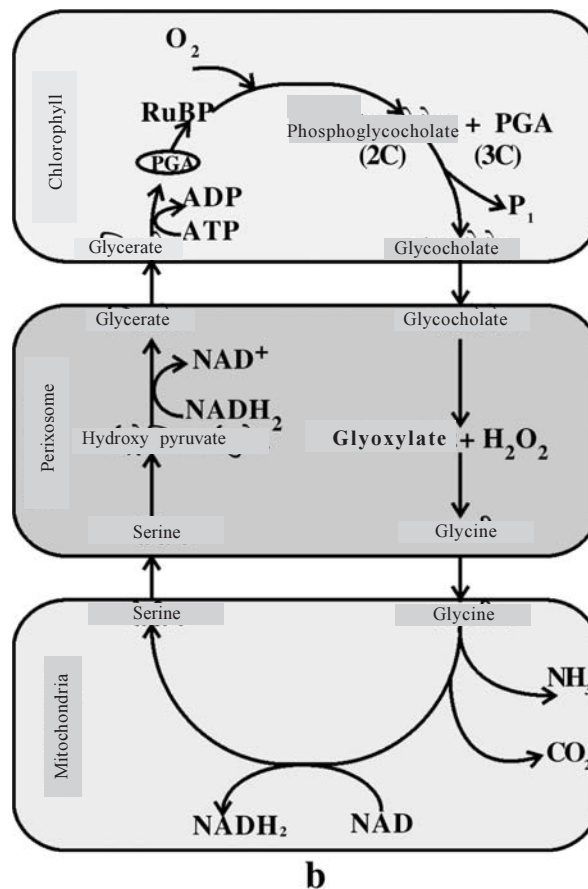
Photorespiration :

- **Definition :** The respiration which occurs in chloroplast in presence of light is known as photorespiration.
- **Location :** Chloroplast, Peroxisome and Mitochondria.
- **Enzyme :** RuBisCo.



- CO_2 and RuBP combines to form 2 PGA in biosynthetic phase which is known as carboxylation.
- Enzyme RuBisCo (Ribulose Biphosphate Carboxylase) is responsible for this process which is in abundant amount.
- It can bind with O_2 and CO_2 .
- In photorespiration it is oxygenase means behaves as enzyme for O_2 .

Chart explaining photorespiration



Importance :

- RuBP is oxygenated in presence of O_2 forming one molecule of 2C phosphoglycolate and next 1 glycine is formed. Such two glycine $\times 2 = 4C$, 3C serine is formed and 1C is removed as release of CO_2 .
- So, Total 4 carbon (100%)
 - 3 carbon (75%)
 - 1 CO_2 (25%) is wasted
- Under condition of intense light and poor availability of CO_2 photorespiration plays defensive role.
- With insufficient availability of CO_2 and light energy cannot be fully utilized and excess light can cause photooxidation and damage the plant. Photorespiration provides protection against this.
- In C_3 plants some O_2 binds to RuBisco and so CO_2 fixation is decreased.
- In C_4 plants photorespiration does not occur. This is because they have a mechanism that increases the concentration of CO_2 at the enzyme site.
- This ensures that RuBisco functions as Carboxylase minimizing Oxygenase activity.
- So productivity is C_4 is more.

- (74) What decreases photorespiration ?
 (A) Fe^{+2} (B) Mg^{+2} (C) H_2O (D) CO_2
- (75) Photorespiration is harmful to plants ? Why ?
 (A) ATP production does not occur. (B) RuBP is decomposed.
 (C) CO_2 is synthesized. (D) Amino acid is decomposed.
- (76) Photorespiration occurs.....
 (A) At low temperature (B) More O_2 and less CO_2
 (C) Low intensity of light (D) Less O_2 and more CO_2
- (77) What is produced by dephosphorylation of phosphoglycolate during photorespiration ?
 (A) Glycerate (B) Glycine (C) Glycolate (D) Glyoxylate
- (78) In which organelle CO_2 is released in photorespiration ?
 (A) Mitochondria (B) Chloroplast (C) Peroxisome (D) Lysosome
- (79) Which is the substrate for photorespiration ?
 (A) Glycine (B) Serine (C) Glycolate (D) RuBP
- (80) By which process Glycolate is formed from phosphoglycolate ?
 (A) Reduction (B) Decarboxylation (C) Phosphorylation (D) Dephosphorylation
- (81) In photorespiration, Glycolate is produced in
 (A) Chloroplast (B) In mitochondria (C) In cytoplasm (D) In peroxisome
- (82) Which product is formed when RuBP is oxygenated ?
 (A) Phosphoglycolate, PGA (B) PGA, DHA
 (C) Phosphoglycolate, Serine (D) Glyceric Acid, PGA
- (83) Which of following is not true for photorespiration ?
 (A) It occurs in presence of light (B) It occurs in chloroplast
 (C) Speciality of C_3 plants (D) Speciality of C_4 plants

Answers : (74-D), (75-B), (76-B), (77-C), (78-A), (79-C), (80-D), (81-A), (82-A), (83-D)

Factors affecting photosynthesis :

The rate of photosynthesis is very important in determining the yields of plants including crop plants. Photosynthesis is under the influence of several factors, both internal and external. When several factors affect any (bio) chemical process.

(1) Chemical process :

- Blackman's (1905) law of limiting factors comes into effect. This states the following :
- "If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value : it is the factor which directly affects the process if its quantity is changed."
- For example, despite of presence of green leaf, optimal light and CO_2 conditions, photosynthesis may not occur, if temperature is very low. This leaf, if given the optimal, temperature, will start photosynthesizing.

(2) Light :

- Both, the intensity and quality of light influence photosynthesis : Normally as intensity of light increases, the rate of photosynthesis increases. However, at higher intensity it is not so. At high intensity of light, oxidation of chlorophyll, occurs and it is decomposed. This is called photooxidation. Because of this the rate of the process drops.
- The visible spectrum of light ranges from 400 nm to 700 nm plants can absorb light from this range only. The rate increases in orange and red light. It decreases in green light.

(3) CO₂ Concentration :

The concentration of CO₂ is very low in the atmosphere i.e. 0.036%. Increase in the concentration upto 0.05% can cause an increase in CO₂ fixation rates. Beyond this the levels for can become damaging over longer periods.

- At high light intensity both, C₃ and C₄ plants show increase in the rates of photosynthesis.
- C₃ plants responds to increased CO₂ concentration and saturation is seen only beyond 450 μl L⁻¹.
- C₄ plants show saturation at about 360 μl L⁻¹.

(4) Temperature :

- (a) There is no notable effect of temperature in the photochemical phase but as dark reaction or biosynthetic phase being enzymatic, temperature has a remarkable effect on it.
- (b) The C₄ plants respond to higher temperatures and show higher rate of photosynthesis while C₃ plants have a much lower temperature optimum.

(5) Water :

- When availability of water is reduced, the plant experiences water stress.
- One is that the stomata are closed, as a result the amount of available CO₂ is reduced.
- Secondly, as water potential in leaves is lowered, they curl. Thus available leaf area is reduced for photosynthesis.

(84) In which temperature range rate of photosynthesis is maximum ?

- (A) 10 °C to 20 °C (B) 5 °C to 10 °C (C) 10 °C to 25 °C (D) 10 °C to 15 °C

(85) Which plants shows decreasing rate of photosynthesis in CO₂ concentration ?

- (A) C₃ plants (B) C₄ plants (C) Aquatic plants (D) CAM plants

(86) Maximum absorption of light occurs at wavelength.

- (A) 400 nm 700 nm (B) 600 nm 1200 nm (C) 600 nm 700 nm (D) 500 nm 900 nm

(87) At high intensity of light

- (A) Rate of photosynthesis increases (B) Rate of photosynthesis decreases
(C) Oxidation of chloroplast occur (D) Reduction of chloroplast occur

(88) What happens when the amount of water decreases in plants ?

- (A) Closing of stomata (B) Decrease in CO₂ concentration
(C) Rolling of leaves as water potential decrease (D) All of the above

- (89) What happens when the temperature increases in the atmosphere ?
 (A) Rate of photosynthesis decreases in C_4 plants.
 (B) Rate of photosynthesis decrease in C_3 plants.
 (C) Rate of photosynthesis increases in C_4 plants.
 (D) Rate of photosynthesis becomes minimum in C_3 plants.
- (90) When does C_4 plant show saturation ?
 (A) $360 \mu l^{-1}$ of CO_2 (B) $350 \mu l^{-1}$ of CO_2 (C) $400 \mu l^{-1}$ of CO_2 (D) $436 \mu l^{-1}$ of CO_2
- (91) is the important for structure of chlorophyll.
 (A) Magnesium (B) Nitrogen (C) Phosphorus (D) Iron
- (92) Which process of photosynthesis show effect of temperature ?
 (A) Light reaction (B) Dark reaction
 (C) Cyclic photophosphorylation (D) Photorespiration

Answers : (84-C), (85-B), (86-A), (87-C), (88-D), (89-C), (90-A), (91-B), (92-B)

A - Assertion, R - Reason.

Choose the correct option :

(A) A and R both are true and R is the correct explanation of A.

(B) A and R both are correct, R is not correct explanation of A.

(C) A is true, but R is false.

(D) A is false, but R is true.

- (93) Assertion A : ATPase present in thylakoid membrane in chloroplast possess two component.
 Reason R : F_0 is embedded in the membrane and F_1 protudes on the outer surface of thylakoid membrane.
 (A) (B) (C) (D)
- (94) Assertion A : During photorespiration NAD is reduced in peroxisome and NADH is dehydrogenated in mitochondria.
 Reason R : During photorespiration ATP is dephosphorylated to form PGA from glycerine.
 (A) (B) (C) (D)
- (95) Assertion : O_2 is released from $4OH^-$ produced from photolysis of water.
 Reason R : NADP are reduced by $4OH^+$ of photolysis of water.
 (A) (B) (C) (D)
- (96) Assertion A : 6 times kelvin cycle occur for formation of 1 glucose.
 Reason R : 18 ATP and 12 $NADPH_2$ are utilised for formation of 1 glucose.
 (A) (B) (C) (D)
- (97) Assertion A : Rubisco is more active as carboxylase and less active as oxigenase.
 Reason R : Productivity is more in C_4 pathway.
 (A) (B) (C) (D)
- (98) Assertion A : There is no possibility of photosynthesis if termperature is less though amount of CO_2 and light is minimum.
 Reason R : Plants follow blackman's law of limiting factor.
 (A) (B) (C) (D)

- (99) Assertion A : If one molecule of RuBP and oxygen occurs the last product is glycine and PGA.
Reason R : If one molecule of RuBP and O_2 the last product is PGA and phosphoglycolate.
(A) (B) (C) (D)
- (100) Assertion A : In C_4 plants PEP is the first CO_2 acceptor and RuBP is last acceptor.
Reason R : In C_3 plants RuBP is first CO_2 acceptor.
(A) (B) (C) (D)
- (101) Assertion A : The rate of photosynthesis is less at high intensity of light.
Reason R : At high intensity of light chloroplast oxidation occur.
(A) (B) (C) (D)
- (102) Assertion A : In light reaction absorption of light, photolysis, release of oxygen, formation of ATP and NADP occurs.
Reason R : LHC creates PS-I and PS-II
(A) (B) (C) (D)

Answers : (93-A), (94-D), (95-B), (96-A), (97-A), (98-B), (99-A), (100-C), (101-D), (102-B)

True - False (T - F) type questions :

Choose the correct True and False :

- (103) (1) Kranz anatomy is seen in C_4 -plants.
(2) Melvin-Kelvin found C_4 -path.
(3) Photorespiration can be seen in C_3 -plants.
(4) 6 ATP and 4 $NADPH_2$ are necessary for fixation of $2CO_2$ in C_3 cycle.
(A) F T T F (B) T F T T (C) T T F T (D) F T F T
- (104) (1) Photolysis occur in stroma of chloroplast.
(2) $NADPH_2$ produced by photolysis are used in light reaction.
(3) Electron and NADP are produce from PS-I are utilise in photolysis.
(4) Mn^{+2} , Ca^{+2} and Cl^- are necessary for photolysis of water.
(A) F T F T (B) T T T F (C) F F T T (D) F T T F
- (105) (1) The first stable product of bio synthetic is PGA.
(2) Non cyclic photophosphorylation occurs in stroma of chloroplast.
(3) Rate of photosynthesis is more in red light.
(4) Light energy is converted into chemical energy during photosynthesis.
(A) T F T T (B) T F F T (C) F F T F (D) F T F T 111

- (106) (1) Light reaction occurs in grana of chloroplast.
 (2) Temperature factor affects biosynthetic phase.
 (3) Chlorophyll-b works as reaction centre.
 (4) Productivity of C_4 is less comparatively to C_3 plants.
 (A) F T T F (B) T T F T (C) F T F T (D) T T F F

- (107) (1) Hatch-Slack found C_3 plants.
 (2) Photorespiration does not occur in C_4 cycle.
 (3) Law of limiting factor is found by blackman.
 (4) The plants which use PEP during CO_2 fixation are called C_4 plants.
 (A) F T T F (B) T F T F (C) F T T T (D) T F F T

- (108) Choose Correct pair :

Column - I	Column - II	
P. Grana region of Chloroplast	(i) Kreb's cycle	(A) P - ii, Q - iii, R - iv, S - i
Q. Stroma region of Chloroplast	(ii) Light reaction	(B) P - i, Q - ii, R - iii, S - iv
R. Cytoplasm	(iii) Dark reaction	(C) P - ii, Q - i, R - iv, S - iii
S. Mitochondrial cytoplasm	(iv) Glycolysis	(D) P - iii, Q - iv, R - i, S - ii

- (109) Choose Correct pair :

Column - I	Column - II	
P. Carboxylation	(i) Production of O_2	(A) P - ii, Q - ii, R - iii, S - iv, T - v
Q. Photophosphorylation	(ii) Photorespiration	(B) P - iii, Q - v, R - i, S - ii, T - iv
R. Photolysis	(iii) RuBiSCo	(C) P - i, Q - iii, R - iii, S - iv, T - ii
S. Phosphoglycolate	(iv) Chemosynthesis	(D) P - i, Q - iii, R - iv, S - ii, T - v
T. Nitrosomonas	(v) ATP	

- (110) Choose Correct pair :

Column - I	Column - II	
1. PS-I	P. Chemiosmotic hypothesis	(A) 1 - Q, 2 - R, 3 - P, 4 - S
2. PS-II	Q. Cyclic photophosphorylation	(B) 1 - Q, 2 - S, 3 - P, 4 - R
3. Cytochrome-b	R. Present in thylakoid	(C) 1 - Q, 2 - R, 3 - S, 4 - P
4. ATPase	S. Photolysis of water	(D) 1 - R, 2 - S, 3 - Q, 4 - P

- (111) Choose Correct pair :

Column - I	Column - II	
1. Cyclic photophosphorylation	P. O_2 is released and NADP is reduced	
2. Biosynthetic phase	Q. Depends on concentration of O_2 and CO_2	
3. Non cyclic photophosphorylation	R. Formation of 2ATP	
4. Photorespiration	S. Photorespiration phase occurs in stroma	
(A) (1-R), (2-P), (3-Q), (4-S)	(B) (1-r), (2-S), (3-Q), (4-P)	
(C) (1-R), (2-S), (3-P), (4-Q)	(D) (1-P), (2-R), (3-Q), (4-S)	

(112) Choose Correct pair :

Column - I

1. $C_6H_{12}O_6$
 2. OAA
 3. RuBP
 4. Glycin
- (A) (1-R), (2-S), (3-Q), (4-P)
(C) (1-S), (2-R), (3-P), (4-Q)

Column - II

- P. Regenerated during process of C_3 cycle
Q. Amino acid produced in peroxisome
R. Product of photosynthesis
S. First stable product of C_4 path
- (B) (1-R), (2-S), (3-P), (4-Q)
(D) (1-R), (2-P), (3-DS), (4-Q)

(113) Choose Correct pair :

Column - I

- P. C_4 Chloroplast
Q. First acceptor of C_3
R. First acceptor of C_4
S. C_3 Chloroplast
- (A) P - s, Q - r, R - p, S - q
(C) P - q, Q - p, R - s, S - r

Column - II

- p. RuBP
q. With Grana and without grana
r. Possess Grana
s.. PEP
- (B) P - r, Q - s, R - p, S - q
(D) A - q, Q - p, R - r, S - s

(114) Choose Correct pair :

Column - I

1. 1733-1804
 2. 1897-1985
 3. 1854
 4. 1730-1799
- (A) (1-p), (2-s), (3-r), (4-q)
(C) (1-p), (2-s), (3-t), (4-q)

Column - II

- p. Time period of priestly
q. Time period of Ingenhousz
r. Time period of Julius Von Sachs
s. Time period of Cornelius Van Niel
t. Time period of Robert Hill
- (B) (1-p), (2-q), (3-r), (4-s)
(D) (1-p), (2-r), (3-s), (4-q)

(115) Choose Correct pair :

Column - I

1. Photolysis of water $\rightarrow$
2. ATP ase $\rightarrow$
3. RuBisCo $\rightarrow$
4. NAD^+ reduction $\rightarrow$

Column - II

- p. Non cyclic photophosphorylation
q. Peroxisome
r. Mitochondria
s. Thylakoid membrane
t. Stroma
- (A) 1 - t, 2 - p, 3 - q, 4 - p
(C) 1 - p, 2 - s, 3 - t, 4 - r
(A) T, P, Q, R (B) T, R, S, P (C) P, S, T, R (D) P, S, T, Q
- (B) 1 - t, 2 - r, 3 - s, 4 - p
(D) 1 - p, 2 - s, 3 - t, 4 - q

Answers : (103-B), (104-C), (105-A), (106-D), (107-C), (108-A), (109-B), (110-B), (111-C), (112-B), (113-C), (114-A), (115-D)

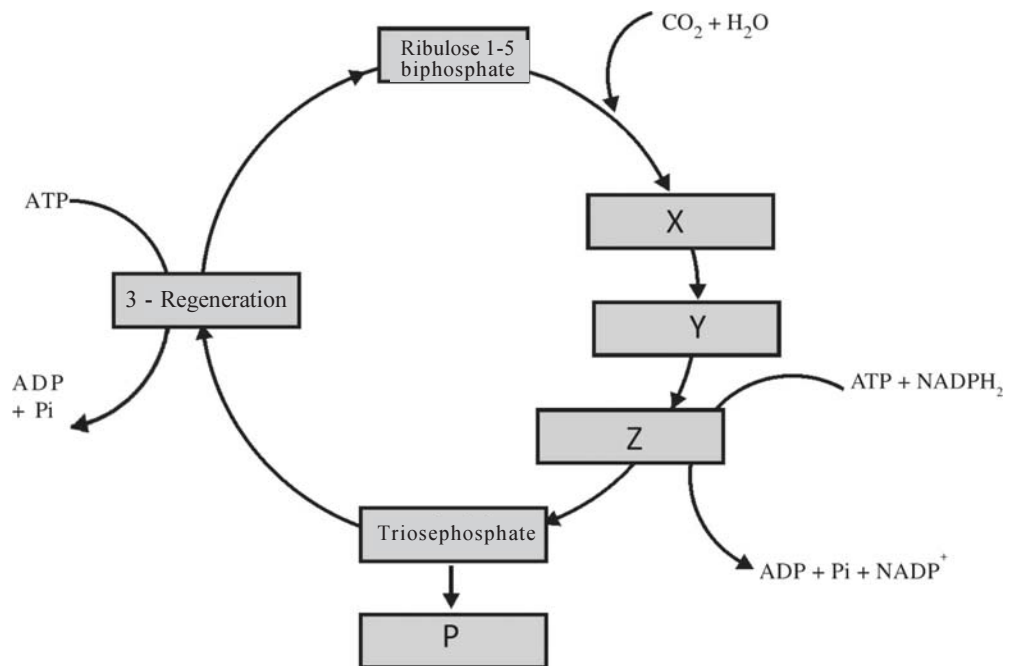


Chart-1

- (116) What is shown in the chart-1 ?
 (A) Reduction (B) Oxidation (C) Carboxylation (D) Decarboxylation
- (117) Which process is indicated by Z in chart-1 ?
 (A) Reduction (B) Carboxylation (C) Oxidation (D) Decarboxylation
- (118) Which process is indicated by Y in chart-1 ?
 (A) 3-Phosphoglycerate (B) 2-Phosphoglycolate (C) Triosphosphate (D) Decarboxylation
- (119) Name chart-1
 (A) C_4 path (B) Kreb's cycle (C) CAM pathway (D) Calvin cycle
- (120) What is indicated as P in chart-1 ?
 (A) Sucrose, Starch (B) Fructose, Starch (C) Maltose, Starch (D) Glucose, Starch

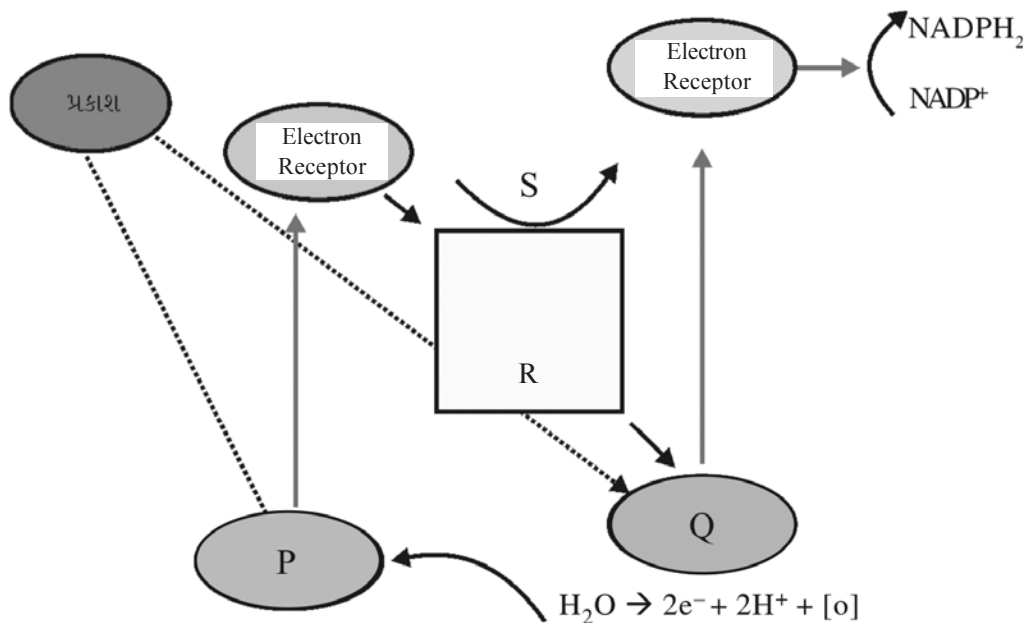
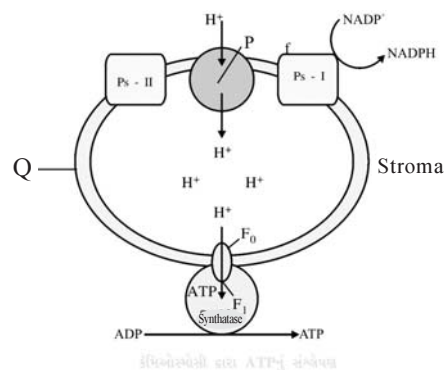


Chart-2

- (121) Name chart-2
 (A) Cyclic photophosphorylation (B) Photorespiration
 (C) Non-cyclic photophosphorylation (D) Photolysis
- (122) What is indicated by P in chart-2 ?
 (A) P_{700} (B) P_{680} (C) P_{670} (D) P_{750}
- (123) What is indicated as Q in chart-2 ?
 (A) P_{700} (B) P_{750} (C) P_{680} (D) P_{580}
- (124) What is indicated by R in chart-2 ?
 (A) Thylakoid membrane (B) Cytoplasmic stroma
 (C) Electron transport system (D) Mitochondria
- (125) Which process is indicated by S in chart-2 ?
 (A) $ATP + ADP + Pi$ (B) $ADP + Pi \rightarrow ATP$
 (C) $2H_2O_2 \rightarrow 2H_2O + O_2$ (D) $CO_2 + H_2O \rightarrow CH_2O + O_2$
- (126) What is indicated by P and Q in the chart ?
 (A) P – Cytochrome A & A, Q – Thylakoid membrane
 (B) P – Thylakoid membrane, Q – Cytochrome A & A
 (C) P – Cytochrome b & f, Q – Cytochrome a & a
 (D) P – Stroma, Q – Thylakoid membrane
- (127) Which process is indicated by this figure ?
 (A) ATP synthesis by chemiosmosis (B) Food synthesis by chemiosmosis
 (C) Photolysis by chemiosmosis (D) Electron transport by chemiosmosis



Answers : (116-C), (117-A), (118-A), (119-D), (120-A), (121-C), (122-B), (123-A), (124-C), (125-B), (126-C), (127-A)

Questions for NEET :

- (128) Which of the following step is necessary for photosynthesis ?
 (A) ATP formation
 (B) Photolysis of water
 (C) Production of chlorophyll with the help of photon
 (D) Production of $C_6H_{12}O_6$
- (129) Who found the laws of limiting factors of photorespiration ?
 (A) Hill (B) Blackman (C) Niel (D) Calvin
- (130) How many H^+ ions are formed by photolysis of $12H_2O$ during Non-cyclic photophosphorylation ?
 (A) $24H^+$ (B) $12H^+$ (C) $36H^+$ (D) $32H^+$

- (131) In which light the rate of photosynthesis is more ?
 (A) Blue (B) Green (C) Orange or Red (D) Blue or Green
- (132) What happens due to absorption of light ?
 (A) Release of O_2 (B) Absorption of CO_2
 (C) Oxidation of chlorophyll (D) Reduction of chlorophyll
- (133) What is correct for C_4 plant ?
 (A) CO_2 combines with PEP (B) CO_2 combines with PGA
 (C) CO_2 combines with PGAL (D) CO_2 combines with RuBP
- (134) How many glycine molecules are necessary to release CO_2 during photorespiration ?
 (A) 1 (B) 3 (C) 2 (D) 4
- (135) Where does the process of Reduction of NAD occurs during photorespiration ?
 (A) Chloroplast and Peroxisome (B) Chloroplast and Mitochondria
 (C) Mitochondria and Peroxisome (D) Mitochondria
- (136) What happens when we put plants in lower intensity of light ?
 (A) Photosynthetic unit becomes more active because of light.
 (B) More CO_2 fixation occurs in presence of light in plants.
 (C) Root system develops more.
 (D) Leaves are converted into thorns.
- (137) Where we find Hill-reaction ?
 (A) Higher level of plants (B) In complete darkness
 (C) During waterstress (D) In presence of fatty cyanide
- (138) Which of the following is incorrect for photorespiration ?
 (A) Associated with chloroplast (B) Occurs during daytime
 (C) Speciality of C_4 plants (D) Speciality of C_3 plants
- (139) In which organism chlorophyll is absent during photosynthesis ?
 (A) Bacteria (B) Cyanobacteria (C) Red algae (D) Brown algae
- (140) Which minerals are necessary for the formation of chlorophyll ?
 (A) Fe, Mg (B) Ca, K (C) Fe, Ca (D) Ca, Cu
- (141) What is true for puruvic acid in CAM plants ?
 (A) Increases during day time (B) Decreases during night
 (C) Decreases during day time (D) Increases during night
- (142) How many e^- are utilise for formation of 1 mole glucose and $6O_2$ molecule ?
 (A) 6 (B) 12 (C) 18 (D) 24
- (143) What is present in blue algae ?
 (A) Chlorophyll (B) Xanthophyll (C) Phycocyanin (D) Fucoxanthnin

- (144) Choose the correct sequence for Kelvin cycle :
- (1) ATP and NADPH formed during photosynthesis are utilised and forms carbohydrate.
 - (2) It is the process in which Ribulose 1, 5 biphosphate except CO_2 and RuBP is regenerated.
 - (3) It is the process in which ribulose 1, 5 biphosphate bind with CO_2 or carboxylation occur.
- (A) 3 – 1 – 2 (B) 3 - 2 - 1 (C) 1 - 2 - 3 (D) 2 - 1 - 3
- (145) Which of the following statement is appropriate for light and process of photosynthesis ?
- (A) Cytochrome a stimulates 680 nm, PS-I stimulates 700 nm, PS-II absorb move photons.
 - (B) Na^+ and Mg ions are necessary for photolysis of water.
 - (C) O_2 participates in photophosphorylation.
 - (D) PS-I and PS-II both participate in iron cyclic photophosphorylation.
- (146) Productivity of C_3 plant are more because
- (A) Photorespiration is less in it (B) Leaf area is more
 - (C) More amount of chloroplast occur in leaves (D) Thin cuticle layer is present
- (147) Which enzyme is responsible for fixation of CO_2 with PEP in mesophyll of C_4 plants ?
- (A) Pyruvate dehydrogenase (B) PEP Carboxylase
 - (C) Pyruvate decarboxylase (D) RuBisco

Answers : (128-C), (129-B), (130-C), (131-C), (132-C), (133-A), (134-C), (135-B), (136-A), (137-A), (138-C), (139-B), (140-A), (141-A), (142-B), (143-A), (144-A), (145-D), (146-C), (147-D)

