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Photosynthesis

TOPIC 1
Site and Pigments Involved in Photosynthesis

01 One scientist cultured *Cladophora* in a suspension of *Azotobacter* and illuminated the culture by splitting light through a prism. He observed that bacteria accumulated mainly in the region of **[NEET (Odisha) 2019]**

(a) violet and green light
(b) indigo and green light
(c) orange and yellow light
(d) blue and red light

Ans. *(d)*

Engelmann used a prism to split light into its spectral components and then illuminated a green alga, *Cladophora* placed in a suspension of aerobic bacteria (*Azotobacter*). The bacteria were used to detect the sites of oxygen evolution.

He observed that bacteria mainly accumulated in the region of blue and red light of the split spectrum, thus giving the first action spectrum of photosynthesis.

02 In a chloroplast the highest number of protons are found in **[NEET 2016, Phase I]**

(a) lumen of thylakoids
(b) inter membrane space
(c) antennae complex
(d) stroma

Ans. *(a)*

Proton concentration is higher in the lumen of thylakoid due to photolysis of water, H^+ pumping and NADP reductase activity which occurs in stroma of the chloroplast.

03 Of the total incident solar radiation the proportion of PAR is **[CBSE AIPMT 2011]**

(a) about 60% (b) less than 50%
(c) more than 80% (d) about 70%

Ans. *(b)*

PAR (Photosynthetically Active Radiation) designates the spectral range of solar radiation from 400-700 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%.

04. Stroma in the chloroplasts of higher plants contains **[CBSE AIPMT 2009]**

(a) light-independent reaction enzymes
(b) light-dependent reaction enzymes
(c) ribosomes
(d) chlorophyll

Ans. *(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.

05 Carbohydrates are commonly found as starch in plant storage organs. Which of the following five properties of starch (A–E) make it useful as a storage material?

A. easily translocated
B. chemically non-reactive
C. easily digested by animals
D. osmotically inactive
E. synthesised during photosynthesis

The useful properties are **[CBSE AIPMT 2008]**

(a) B and C (b) B and D
(c) A, C and E (d) A and E

Ans. *(c)*

Option (c) is correct. As starch is a high molecular weight polymer of D-glucose in α $1 \rightarrow 4$ linkage. It is synthesised in chloroplasts as one of the stable end products of photosynthesis. It is most abundant and common storage polysaccharide in plants hence, most staple food for man and herbivores.

It is a mixture of two types of glucose homopolysaccharide *viz*, amylose and amylopectin. During day time the starch synthesis in chloroplast is coordinated with sucrose synthesis in cytosol. Typically about 90% of total solute carried in phloem is the carbohydrate sucrose, a disaccharide.

This is relatively inactive and highly soluble sugar playing little direct role in metabolism and so, making an ideal transport sugar.

06 Chlorophyll in chloroplasts is located in **[CBSE AIPMT 2004]**

(a) outer membrane
(b) inner membrane
(c) thylakoids (d) stroma

Ans. *(c)*

The thylakoids of chloroplast are flattened vesicles arranged as a membranous network within the stroma. 50% of chloroplast proteins and various components involved (namely chlorophyll, carotenoids and plastoquinone) in photosynthesis are present in thylakoid membranes.

07 Which fractions of the visible spectrum of solar radiations are primarily absorbed by carotenoids of the higher plants? **[CBSE AIPMT 2003]**

(a) Violet and blue (b) Blue and green
(c) Green and red (d) Red and violet

Ans. *(a)*

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.

08 Which element is located at the centre of the porphyrin ring in chlorophyll? **[CBSE AIPMT 2003]**

(a) Manganese (b) Calcium
(c) Magnesium (d) Potassium

Ans. *(c)*

Magnesium is at the centre of the porphyrin ring in chlorophyll. The general structure of chlorophyll was elucidated by Hand Fischer in 1940.

09 Stomata of CAM plants **[CBSE AIPMT 2003]**

(a) open during the night and close during the day
(b) never open
(c) are always open
(d) open during the day and close at night

Ans. *(a)*

CAM (Crassulacean Acid Metabolism) plants open stomata only at night (when temperature is low and humidity is high) to cause lesser loss of water (e.g. *Agave*, *Opuntia*, etc.). So, CAM photosynthesis is a carbon fixation pathway that evolved in some plants as an adaptation to arid condition.

10 The first step of photosynthesis is **[CBSE AIPMT 2000]**

(a) excitation of electron of chlorophyll by a photon of light
(b) formation of ATP
(c) attachment of CO_2 to 5 carbon sugar
(d) ionisation of water

Ans. *(a)*

The entire process of photosynthesis is driven by light energy coming from the sun. This energy is first captured by chlorophyll molecules and later on utilised for the synthesis of ATP (chemical energy) molecules which are later utilised in the dark reaction, i.e., Calvin cycle.

11 Chlorophyll-*a* molecule at its carbon atom 3 of the pyrrole ring-II has one of the following **[CBSE AIPMT 1996]**

(a) aldehyde group
(b) methyl group
(c) carboxyl group
(d) magnesium

Ans. *(a)*

Chlorophyll has a tetrapyrrole porphyrin head and a long chain alcohol called phytol tail. Each pyrrole is a 5 member ring with one nitrogen and four carbon. A non-ionic Mg atom lies in the centre of porphyrin, attached to nitrogen atoms of pyrrole rings. Chlorophyll-*a* has methyl group at carbon 3 of pyrrole ring and chlorophyll-*b* has formyl (aldehyde) group attached to this atom.

12 Pigment acting as a reaction centre during photosynthesis is **[CBSE AIPMT 1994]**

(a) carotene
(b) phytochrome
(c) P_{700}
(d) cytochrome

Ans. *(c)*

Photosynthetic pigment molecules (e.g. P_{700}, P_{680}) are able to convert light energy into chemical energy. These pigment molecules which together forms the photosynthetic units, possess photocentres (reaction centre = trap centre) surrounded by harvesting molecules differentiated into core molecules and antenna molecules.

13 Nine-tenth of all photosynthesis of world (85-90%) is carried out by **[CBSE AIPMT 1994]**

(a) large trees with millions of branches and leaves
(b) algae of the ocean
(c) chlorophyll containing ferns of the forest
(d) scientists in the laboratories

Ans. *(b)*

90% of total photosynthesis is carried out by aquatic plants, chiefly algae (80% in oceans and 10% in freshwater). 10% of total photosynthesis is performed by land plants.

14 Maximum solar energy is trapped by **[CBSE AIPMT 1993]**

(a) planting trees
(b) cultivating crops
(c) growing algae in tanks
(d) growing grasses

Ans. *(d)*

Maximum solar energy is trapped by growing grasses, as they have the largest surface area for absorption. Limited number of algal individual are growing in tank so, they absorb limited amount of light.

15 Chlorophyll-*a* occurs in **[CBSE AIPMT 1992]**

(a) all photosynthetic autotrophs
(b) in all higher plants
(c) all oxygen liberating autotrophs
(d) all plants except fungi

Ans. *(b)*

Chlorophyll-*a* ($C_{55}H_{72}O_5N_4Mg$) is a bluish green pigment, it is the primary photosynthetic pigment or universal photosynthetic pigment that occurs in all plants except photoautotrophic bacteria, i.e. found in all oxygenic photoautotrophs.

16 Photosynthetic pigments found in the chloroplasts occur in **[CBSE AIPMT 1991]**

(a) thylakoid membranes
(b) plastoglobules
(c) matrix
(d) chloroplast envelope

Ans. *(a)*

Photosynthetic pigments are those pigments which occur on photosynthetic thylakoids of chloroplasts and absorb light energy for the purpose of photosynthesis. These are mainly of two types—chlorophylls and carotenoids.

17 The size of chlorophyll molecule is **[CBSE AIPMT 1988]**

(a) head 15×15 Å, tail 25 Å
(b) head 20×20 Å, tail 25 Å
(c) head 15×15 Å, tail 20 Å
(d) head 10×12 Å, tail 25 Å

Ans. *(c)*

A chlorophyll molecule consists of two parts, the porphyrin ring (head) 15×15 Å and a phytol tail (20 Å).

TOPIC 2
Light Reaction

18 Which of the following statement is incorrect? **[NEET 2021]**

(a) Both ATP and NADPH + H^+ are synthesised during non-cyclic photophosphorylation
(b) Stroma lamellae have PS-I only and lack NADP reductase
(c) Grana lamellae have both PS-I and PS-II
(d) Cyclic photophosphorylation involves both PS-I and PS-II

Ans. *(d)*

Statement in option (d) is incorrect and can be corrected as

Only photosystem I is involved in cyclic photophosphorylation process. Cyclic photophosphorylation is a process in which an electron expelled by the excited photocentre is returned to it after passing through a series of electron carriers. The excited electron does not pass on to $NADP^+$ but is cycled back to the PS I complex through the electron transport chain.

Non-cyclic photophosphorylation involves both photosystems I and II. The electron follows a non-cyclic pathway in it. The representation of it is also called Z scheme.

19 In light reaction, plastoquinone facilitates the transfer of electrons from **[NEET (Sep.) 2020]**

(a) Cyt-b_6f complex to PS-I
(b) PS-I to $NADP^+$
(c) PS-I to ATP synthase
(d) PS-II to Cyt-b_6f complex

Ans. *(d)*

In light reaction, plastoquinone facilitates the transfer of electrons from PS II to cytochrome b_6f complex (non-cyclic photophosphorylation) process of light reaction starts with PS II (680 nm). When sunlight falls on the reaction center (chlorophyll, *a*) it abosrbs 680 nm wavelength of red light causing electrons to become excited and jump into an orbit farther from the atomic nucleus. These electrons are picked by the electron acceptor which passes them to an electron transport system consisting of cytochrome b_6 complex.

20 Which of the following is not a product of light reaction of photosynthesis? **[NEET 2018]**

(a) NADPH (b) NADH
(c) ATP (d) Oxygen

Ans. *(b)*

During light reaction of photosynthesis NADPH, ATP and oxygen are formed. **Oxygen** is liberated by the photolysis of water.

$$4H_2O \rightleftharpoons 4H^+ + 4OH^-$$

$$4OH^- \xrightarrow[Mn^{2+},\ Ca^{2+},\ Cl^-]{\text{Oxygen-Evolving complex}} 2H_2O + O_2\uparrow + 4e^-$$

The electrons released during photolysis of water are picked up by P_{680} photocentre of PS-II. On receiving light energy photocentre expels an electron which passes over a series of carriers.

As a result assimilatory power, i.e. **ATP** and **NADPH** is produced. **NADH** is formed during respiration.

21 In photosynthesis, the light-independent reactions take place at **[CBSE AIPMT 2015]**

(a) thylakoid lumen
(b) photosystem-I
(c) photosystem-II
(d) stromal matrix

Ans. *(d)*

The light-independent reactions (or dark reactions) take place in the stromal matrix of the chloroplasts.

In light independent reactions, carbon dioxide is reduced to glucose (carbohydrate) by the hydrogen in NADPH by using the chemical energy stored in ATP. This reaction takes place in the presence of a substance called RuDP.

22 Anoxygenic photosynthesis is characteristic of **[CBSE AIPMT 2014]**

(a) *Rhodospirillum* (b) *Spirogyra*
(c) *Chlamydomonas* (d) *Ulva*

Ans. *(a)*

Anoxygenic photosynthesis (in which O_2 is not released) is seen in *Rhodospirillum* which is a purple non-sulphur bacteria. It helps an organism to trap light energy and store it as chemical energy.

Other than this anoxygenic photosynthesis commonly occurs in purple non-sulphur bacteria, green sulphur/non-sulphur bacteria, and heliobacteria, etc.

23 A process that makes important difference between C_3 and C_4-plants is **[CBSE AIPMT 2012]**

(a) transpiration (b) glycolysis
(c) photosynthesis
(d) photorespiration

Ans. *(d)*

Photorespiration is a light dependent process which occurs in C_3-plants. It is opposite to photosynthesis because during this process, uptake of O_2 and release of CO_2 take place. Due to the presence of Kranz anatomy, C_4-plants do not show photorespiration.

24 Oxygenic photosynthesis occurs in **[CBSE AIPMT 2009]**

(a) *Chromatium* (b) *Oscillatoria*
(c) *Rhodospirillum* (d) *Chlorobium*

Ans. *(b)*

Oscillatoria is a photosynthetic cyanobacterium. In this cyanobacteria during 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, also a non-oxygenic photosynthetic.

25 Cyclic-photophosphorylation results in the formation of **[CBSE AIPMT 2009]**

(a) NADPH
(b) ATP and NADPH
(c) ATP, NADPH and O_2
(d) ATP

Ans. *(d)*

Cyclic-photophosphorylation involves only pigment system-I and results in the formation of ATP only. When the photons activate PS-I, a pair of electrons are raised to a 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 thylakoid membrane. The proton gradient thus established is responsible for forming ATP (2 molecules). No reduction of NADP to NADPH + H^+.

26 The first acceptor of electrons from an excited chlorophyll molecule of photosystem-II is **[CBSE AIPMT 2007, 08]**

(a) cytochrome
(b) iron-sulphur protein
(c) ferredoxin
(d) quinone

Ans. ***(d)***

Plastoquinone is the first acceptor of electrons from an excited chlorophyll molecule of photosystem-II.

27 In photosystem-I the first electron acceptor is **[CBSE AIPMT 2006]**

(a) cytochrome
(b) plastocyanin
(c) an iron-sulphur protein
(d) ferredoxin

Ans. ***(c)***

In photosystem-I, the primary electron acceptor is probably a Fe-S protein. The reduced primary acceptor transfers the electrons to secondary electron acceptor (most probably P_{430}). The sequence of electron transfer is as follows :

$$\underset{(\text{Chl-a}^+)}{P_{700}} \xrightarrow{e^-} \underset{(\text{Phyloquinone})}{A_1} \xrightarrow{e^-} \underset{(\text{Fe-S protein})}{A_2} \xrightarrow{e^-} \underset{(P_{430})}{A_3}$$

The reduced P_{430} passes its electrons to ferredoxin (Fd) present at outer surface of thylakoid membrane.

28 Which of the following absorb light energy for photosynthesis? **[CBSE AIPMT 2002]**

(a) Chlorophyll (b) Water molecule
(c) O_2 (d) RuBP

Ans. ***(a)***

Chlorophyll molecule absorbs light for photosynthesis. H_2O molecules provide H^+ ions and electrons during photosynthesis. O_2 is liberated during photosynthesis. RuBP (Ribulose 1, 5-bisphosphate) reacts with CO_2 during dark reaction of photosynthesis. This process takes place in the presence of enzyme RuBisCO.

29 Which pigment system is inactivated in red drop? **[CBSE AIPMT 2001]**

(a) PS-I and PS-II (b) PS-I
(c) PS-II (d) None of these

Ans. ***(c)***

The fall in photosynthetic yield beyond red region of spectrum (680 nm) is called red drop. Reaction centre of PS-II is P_{680} while that of PS-I is P_{700}. So in the red drop reaction PS-II is inactivated.

30 Photochemical reactions in the chloroplast are directly involved in **[CBSE AIPMT 2000]**

(a) formation of phosphoglyceric acid
(b) fixation of carbon dioxide
(c) synthesis of glucose and starch
(d) photolysis of water and phosphorylation of ADP to ATP

Ans. ***(d)***

CO_2 is fixed in the stroma of the chloroplast leading to the synthesis of PGA from which glyceraldehyde phosphate is formed. From glyceraldehyde phosphate, sugar and starch are formed.

All these do not require light. However, photolysis of water and phosphorylation of ADP to ATP requires light energy.

31 Protochlorophyll differs from chlorophyll in lacking **[CBSE AIPMT 1998]**

(a) 2 hydrogen atoms in one of its pyrrole rings
(b) 2 hydrogen atoms in two of its pyrrole rings
(c) 4 hydrogen atoms in one of its pyrrole rings
(d) 4 hydrogen atoms in two of its pyrrole rings

Ans. ***(a)***

Protochlorophyll differs from chlorophyll in lacking 2 hydrogen atoms in one of its pyrrole rings.

32 NADPH is generated through **[CBSE AIPMT 1997]**

(a) photosystem-I
(b) photosystem-II
(c) anaerobic respiration
(d) glycolysis

Ans. ***(b)***

NADPH is generated through photosystem-II. In non-cyclic photophosphorylation (which involves both PS-I and II) protons released from photolysis and electrons emitted from P_{700} are ultimately passed on to $NADP^+$ resulting in the formation of NADPH.

In cyclic photophosphorylation (which involves only PS-I) electrons flow in a cyclic manner but there is no net formation of NADPH and O_2.

33 Which one occurs both during cyclic and non-cyclic modes of photophosphorylation? **[CBSE AIPMT 1994]**

(a) Involvement of both PS-I and PS-II
(b) Formation of ATP
(c) Release of O_2
(d) Formation of NADPH

Ans. ***(b)***

Cyclic photophosphorylation is that type of light energised ATP synthesis in which electron expelled by excited photocentre does not return to them. It involves two Photochemical Systems (PS-I and PS-II) and produces assimilatory power (ATP and NADPH).

In both, cyclic and non-cyclic photophosphorylation, formation of ATP takes place.

34 Formation of ATP in photosynthesis and respiration is an oxidation process which utilises the energy from **[CBSE AIPMT 1992]**

(a) cytochromes (b) ferredoxin
(c) electrons (d) carbon dioxide

Ans. ***(c)***

Cytochromes (Keilin; 1925) are the electron transport intermediates containing heme (or related prosthetic groups) in which the iron undergoes valency changes during electron transfer and produces energy (ATP) in both photosynthesis and respiration.

35 Photosystem-II occurs in **[CBSE AIPMT 1992]**

(a) stroma (b) cytochrome
(c) grana
(d) mitochondrial surface

Ans. ***(c)***

PS-II is present in appressed part of granal thylakoids. PS-I is present in stroma thylakoids and non-appressed parts of granal thylakoids.

36 Ferredoxin is a constituent of **[CBSE AIPMT 1991]**

(a) PS-I (b) PS-II
(c) Hill reaction (d) P_{680}

Ans. ***(a)***

Ferredoxin (Fd) is a soluble protein which acts as electron carrier and forms a constituent of PS-I. Ferredoxin passes electrons to reductase complex which helps in reducing $NADP^+$ to NADPH (a strong reducing agent).

37 $NADP^+$ is reduced to NADPH in **[CBSE AIPMT 1988]**

(a) PS-I (b) PS-II
(c) Calvin cycle
(d) Non-cyclic photophosphorylation

Ans. *(d)*

In photosynthesis during non-cyclic photophosphorylation involving both PS-I and PS-II, electrons released during photolysis of water are transfered to PS-II and then PS-I via a series of electron carriers. P_{700} of PS-I releases electron after absorbing light energy. This electron passes through chlorophyll X, Fe-S, ferredoxin and finally to $NADP^+$. $NADP^+$ combines with H^+ (released during photolysis) with the help of NADP reductase to form NADPH.

$$NADP^+ + 2e^- + H^+ \xrightarrow[\text{reductase}]{\text{NADP}} NADPH$$

TOPIC 3
Dark Reaction

38 The first stable product of CO_2 fixation in *Sorghum* is **[NEET 2021]**

(a) pyruvic acid
(b) oxaloacetic acid
(c) succinic acid
(d) phosphoglyceric acid

Ans. *(b)*

Carbon fixation or carbon assimilation is the process by which inorganic carbon (particularly in the form of carbon dioxide) is converted to organic compounds by living organisms. The compounds are then used to store energy and as structure for other biomolecules.

Most of the plants that are adapted to dry tropical regions form C-4 acid i.e. oxalic acid as their first stable product. These plants are called C_4 plants. Sugarcane, maize, *Sorghum*, etc. are the examples of these plants.

39 Which of the following statements is incorrect? **[NEET (Oct.) 2020]**

(a) RuBisCO is a bifunctional enzyme
(b) In C_4 plants the site of RuBisCO activity is mesophyll cell
(c) The substrate molecule for RuBisCO activity is a 5-carbon compound
(d) RuBisCO action requires ATP and NADPH

Ans. *(b)*

Statement (b) is incorrect and can be corrected as In C_4 plants, Kranz anatomy in leaf is found due to the presence of two type of cells *viz.*, mesophyll cells and bundle sheath cells.
The mesophyll cells are specialised to perform light reaction, evolve O_2 and produce assimilatory power. The bundle sheath cells possess RuBisCO and thus, perform RuBisCO activity at this site.

40 The oxygenation activity of RuBisCO enzyme in photorespiration leads to the formation of **[NEET (Sep.) 2020]**

(a) 1 molecule of 3-C compound
(b) 1 molecule of 6-C compound
(c) 1 molecule of 4-C compound and 1 molecule of 2-C compound
(d) 2 molecules of 3-C compound

Ans. *(a)*

The oxygenation activity of RuBisCO enzyme in photorespiration leads to the formation of 1 molecule of 3C compound (phosphoglycerate). In C_3 plants during oxygen fixation, one molecule of PGA(3C) and one molecule of 2-phosphoglycolate(2C) are formed. The latter is then converted back to PGA in the photorespiratory cycle. Photorespiration occurs at high concentration of oxygen and temperature in the environment.

41 In Hatch and Slack pathway, the primary CO_2 acceptor is **[NEET (Odisha) 2019]**

(a) oxaloacetic acid
(b) phosphoglyceric acid
(c) phosphoenol pyruvate
(d) RuBisCO

Ans. *(c)*

In Hatch and Slack pathway, the primary CO_2 acceptor is phosphoenol pyruvate. This occurs in C_4-plants. Phosphoenol pyruvate, a 3-carbon compound, accepts CO_2 and forms oxaloacetic acid which is a 4-carbon compound.

42 Phosphoenol Pyruvate (PEP) is the primary CO_2 acceptor in **[NEET 2017]**

(a) C_3-plants (b) C_4-plants
(c) C_2-plants (d) C_3 and C_4-plants

Ans. *(b)*

Phosphoenol Pyruvate (PEP) is found in the mesophyll cell, which accepts the atmospheric CO_2 in C_4-plants and converts it to oxalo acetate -- a C_4 compound. It is the first stable compound of C_4-plants.
Concept Enhancer C_4-plants possess special adaptation anatomy in their leaves to cope up the photorespiratory losses. There are dimorphic chloroplast present in them—agranal in bundle sheath cells and granal in mesophyll cells.

43 A plant in your garden avoids photorespiratory losses, has improved water use efficiency, shows high rates of photosynthesis at high temperatures and has improved efficiency of nitrogen utilisation. In which of the following physiological groups would you assign this plant? **[NEET 2016, Phase I]**

(a) C_4 (b) CAM
(c) Nitrogen fixer (d) C_3

Ans. *(a)*

This plant is a C_4-plant as these group of plants shows little photorespiration, efficient in binding to CO_2 even at low concentrations, better utilisation of water as well as high rates of photosynthesis even at high temperatures, i.e. tropical region. Besides, they can also tolerate excess of salts due to presence of organic acids.

44 PGA as the first CO_2-fixation product was discovered in photosynthesis of **[CBSE AIPMT 2010]**

(a) bryophyte (b) gymnosperm
(c) angiosperm (d) alga

Ans. *(d)*

The use of radioactive ^{14}C by **Melvin Calvin** in algal (*Chlorella*) photosynthesis studies led to the discovery that the first CO_2 fixation product was a 3-carbon organic acid. The first product identified was 3-phosphoglyceric acid (PGA).

45 C_4-plants are more efficient in photosynthesis than C_3-plants due to **[CBSE AIPMT 2010, 08]**

(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

Ans. ***(b)***

C_4-plants are more efficient in photosynthesis than C_3-plants but use more energy. They possess the larger number of chloroplasts in the leaf cells. In the leaves of C_4-plants, the vascular bundles are surrounded by bundle sheath cells which in turn are surrounded by mesophyll cells. Chloroplast in bundle sheath cells are larger and always contain grana, whereas chloroplasts in mesophyll cells are smaller.

46 In the leaves of C_4-plants, malic acid formation during CO_2-fixation occurs in the cells of **[CBSE AIPMT 2007, 08]**

(a) mesophyll (b) bundle sheath
(c) phloem (d) epidermis

Ans. ***(a)***

The oxalic acid is reduced to malic acid in mesophyll cells, from chloroplast of mesophyll cells the malic acid is transferred to the chloroplast of bundle sheath cells where, it is decarboxylated to form CO_2 and pyruvic acid.

47 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 **[CBSE AIPMT 2005]**

(a) 2 (b) 6 (c) 12 (d) zero

Ans. ***(c)***

In C_4-plants every CO_2 molecule has to be fixed twice, so these plants are needed more energy for the synthesis of hexose sugar molecules than C_3-plants in which CO_2 has to be fixed only once. 18 ATP molecules are required by C_3-plants for the synthesis of one molecule of hexose sugar while 30 ATP molecules are needed by the C_4-plants for the same. Thus, C_4-plants have a need of 12 ATP molecules extra than C_3-plants for the synthesis of one molecule of hexose sugar.

48 Photosynthesis in C_4-plants is relatively less limited by atmospheric CO_2 levels because **[CBSE AIPMT 2005]**

(a) effective pumping of CO_2 into bundle sheath cells
(b) RuBisCO in C_4-plants has higher affinity for CO_2
(c) four carbon acids are the primary initial CO_2-fixation products
(d) the primary fixation of CO_2 is mediated *via* PEP carboxylase

Ans. ***(d)***

The fixation of CO_2 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 CO_2 into oxalo acetic acid (4C).

RuBisCO is present in bundle sheath cells where final fixation of CO_2 in hexose sugars takes place. CO_2 is primarily fixed by PEP carboxylase because this enzyme has greater affinity to CO_2 than RuBisCO.

49 In C_3-plants, the first stable product of photosynthesis during the dark reaction is **[CBSE AIPMT 2004]**

(a) malic acid
(b) oxaloacetic acid
(c) 3-phosphoglyceric acid
(d) phosphoglyceraldehyde

Ans. ***(c)***

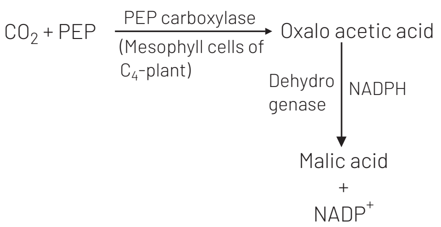
In C_3-plants the first stable product formed during dark reaction is 3-phosphoglyceric acid. Since, it is a 3 carbon compound hence, the pathway is referred as C_3-pathway. Oxalo Acetic Acid (OAA) is the first stable compound in C_4-plants. It is a 4C compound.

50 In sugarcane plant $^{14}CO_2$ is fixed in malic acid, in which the enzyme that fixes CO_2 is **[CBSE AIPMT 2003]**

(a) fructose phosphatase
(b) ribulose bisphosphate carboxylase
(c) phosphoenol pyruvic acid carboxylase
(d) ribulose phosphate kinase

Ans. ***(c)***

In C_4-plants, CO_2 is taken up by Phosphoenol- Pyruvate (PEP) and the reaction being catalysed by PEP carboxylase.



51 In photosynthesis energy from light reaction to dark reaction is transferred in the form of **[CBSE AIPMT 2002]**

(a) ADP (b) ATP
(c) RuDP (d) chlorophyll

Ans. ***(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 CO_2 to carbohydrate in dark reaction.

52 Which pair is wrong? **[CBSE AIPMT 2001]**

(a) C_3—Maize
(b) C_4—Kranz anatomy
(c) Calvin cycle—PGA
(d) Hatch and Slack Pathway—Oxalo acetic acid

Ans. ***(a)***

Maize is a C_4-plant. C_4-plants have Kranz type anatomy of leaves.

PGA (3-Phosphoglyceric Acid) is formed during Calvin cycle.

OAA (Oxalo Acetic Acid) a 4C compound is formed during Hatch and Slack cycle (C_4 cycle).

53 How many turns of Calvin cycle yield one molecule of glucose? **[CBSE AIPMT 2000]**

(a) 8 (b) 2 (c) 6 (d) 4

Ans. ***(c)***

Conversion of CO_2 to simple (reduced) organic compounds is called CO_2 assimilation or CO_2 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 6 carbon atoms.

54 Fixation of one CO_2 molecule through Calvin cycle requires **[CBSE AIPMT 2000]**

(a) 1 ATP and $2NADPH_2$
(b) 2 ATP and $2NADPH_2$
(c) 3 ATP and $2NADPH_2$
(d) 2ATP and $1NADPH_2$

Ans. ***(c)***

2 ATP are required during conversion of PGA to 1, 3 diphosphoglyceric acid and 1

ATP during conversion of glyceraldehyde phosphate to ribulose biphosphate. 2 $NADPH_2$ molecules are utilised for converting 1, 3 diphosphoglyceric acid to glyceraldehyde phosphate.

55 Which one of the following is represented by Calvin cycle? **[CBSE AIPMT 1996]**

(a) Reductive carboxylation
(b) Oxidative carboxylation
(c) Photophosphorylation
(d) Oxidative phosphorylation

Ans. *(a)*

In dark phase or Calvin cycle, carbon dioxide is assimilated with the help of assimilatory power (ATP and $NADPH_2$) to produce organic acid. The cycle involves reduction of carbon involving carboxylation, glycolytic reversal and regeneration of RuBP. C_3 cycle is also known as reductive pentose pathway or Photosynthetic Carbon Reduction (PCR).

56 C_4-cycle was discovered by **[CBSE AIPMT 1994]**

(a) Hatch and Slack (b) Calvin
(c) Hill (d) Arnon

Ans. *(a)*

C_4 pathway or dicarboxylic acid pathway is an alternative path of CO_2-fixation in photosynthesis. It was discovered by MD Hatch and CR Slack in 1967, so also known as Hatch- Slack cycle.

57 The carbon dioxide acceptor in Calvin cycle/ C_3-plants is **[CBSE AIPMT 1993, 95, 96, 99]**

(a) Phosphoenol Pyruvate (PEP)
(b) Ribulose 1,5-Diphosphate (RuDP)
(c) Phosphoglyceric Acid (PGA)
(d) Ribulose Monophosphate (RMP)

Ans. *(b)*

In C_3-plants, CO_2 combines with ribulose biphosphate (acceptor molecule) in the presence of RuBisCO (RuBP carboxylase) and form two molecules of 3-Phosphoglyceric acid or PGA (first stable product).

58 Which one is a C_4-plant? **[CBSE AIPMT 1992]**

(a) Papaya (b) Pea
(c) Potato (d) Maize/Corn

Ans. *(d)*

The plants in which the first stable product of dark reaction of photosynthesis is a 4-carbon compound are called C_4-plants, e.g. sugarcane, maize, sorghum, etc. These plants show characteristic Kranz anatomy. The first CO_2 acceptor in these plants is Phosphoenol Pyruvate (PEP).

59 The enzyme that catalyses initial carbon dioxide fixation in C_4-plants is **[CBSE AIPMT 1992, 2002]**

(a) RuBP carboxylase
(b) PEP carboxylase
(c) carbonic anhydrase
(d) carboxydismutase

Ans. *(b)*

In C_4-plants, mesophyll cells fix carbon dioxide with the help of phosphoenol-pyruvate (the first acceptor) in the presence of PEP carboxylase to a compound oxaloacetic acid (first product).

60 Dark reactions of photosynthesis occur in **[CBSE AIPMT 1991]**

(a) granal thylakoid membranes
(b) stromal lamella membranes
(c) stroma outside photosynthetic lamellae
(d) periplastidial space

Ans. *(c)*

Light reaction of photosynthesis occurs in granal thylakoid membranes of chloroplast while dark reaction occurs in the stroma or matrix, i.e. outside the photosynthetic lamellae of chloroplast.

61 Which technique has helped in investigation of Calvin cycle? **[CBSE AIPMT 1991]**

(a) X-ray crystallography
(b) X-ray technique
(c) Radioactive isotope technique
(d) Intermittent light

Ans. *(c)*

Calvin, Benson and Basshan utilised C^{14} (with long life) to trace the path of carbon in photosynthesis. Calvin was awarded Nobel Prize in 1961 in recognition to his work with C^{14} isotope. He discovered the cycle involved in carbon assimilation, known as Calvin cycle or C_3-cycle.

62 Kranz anatomy is typical of **[CBSE AIPMT 1990, 95]**

(a) C_4-plants (b) C_3-plants
(c) C_2-plants (d) CAM plants

Ans. *(a)*

Leaves of C_4-plants (e.g. sugarcane, maize) are characterised by Kranz anatomy in which the mesophyll is undifferentiated and its cells occur in concentric layers around vascular bundles.

Vascular bundles are surrounded by large sized bundle sheath cells which are arranged in a wreath-like manner (Kranz- wreath).

63 The first carbon dioxide acceptor in C_4-plants is **[CBSE AIPMT 1990, 92]**

(a) phosphoenol-pyruvate
(b) ribulose 1,5-diphosphate
(c) oxalo acetic acid
(d) phosphoglyceric acid

Ans. *(a)*

In C_4-plants, phosphoenol-pyruvate is the first acceptor of CO_2 while ribulose bi-phosphate is the second acceptor. Oxalo Acetic Acid (OAA) is the first product of C_4-cycle.

64 In C_4-plants, Calvin cycle operates in **[CBSE AIPMT 1989]**

(a) stroma of bundle sheath chloroplasts
(b) grana of bundle sheath chloroplasts
(c) grana of mesophyll chloroplasts
(d) stroma of mesophyll chloroplasts

Ans. *(a)*

C_4-plants possess two types of chloroplasts granal in mesophyll cells and agranal in bundle sheath cells.

Mesophyll cells are specialised to perform light reaction and bundle sheath cells possess RuBisCO, here CO_2 is fixed through Calvin cycle.

65 A very efficient converter of solar energy with net productivity of 2-4 kg/m^2 or more is the crop of **[CBSE AIPMT 1989]**

(a) wheat (b) sugarcane
(c) rice (d) bajra

Ans. *(b)*

In C_4-plants, (e.g. maize, sugarcane, sorghum) optimum temperature of photosynthesis is 30–45°C. In C_4-plants, rate of net photosynthesis in full sunlight is (40–80 mg $CO_2/dm^2/hr$) which is more than the rate of net photosynthesis (15–35 mg $CO_2/dm^2/hr$) at optimum sunlight in C_3-plants.

66 Carbon dioxide joins the photosynthetic pathway in **[CBSE AIPMT 1988]**

(a) PS-I (b) PS-II
(c) light reaction (d) dark reaction

Ans. *(d)*

In dark reaction of photosynthesis, reducing agent (NADPH) and source of energy (ATP) formed during light reaction, are utilised in the conversion of CO_2 to carbohydrates.

TOPIC 4
Photorespiration

67 During non-cyclic photophosphorylation, when electrons are lost from the reaction centre at PS-II, what is the source which replaces these electrons? **[NEET (Oct.) 2020]**

(a) Oxygen (b) Water
(c) Carbon dioxide (d) Light

Ans. *(b)*

During non-cyclic photophosphorylation, electrons expelled by the excited PS-II photocentre does not return to it. Therefore, it requires an external electron donor and that purpose is served by water.

H_2O undergo photolysis and the electrons thus released are picked up by PS-II (P_{680}) and handed over to PS-I or P_{700}.

68 The process which makes major difference between C_3 and C_4-plants is **[NEET 2016, Phase II]**

(a) glycolysis
(b) Calvin cycle
(c) photorespiration
(d) respiration

Ans. *(c)*

Photorespiration is the process which makes a difference between the C_3 and C_4-plants. In this process, there is a continuous loss of carbon fixed in the form of CO_2.

It occurs due to the high O_2 content, high temperature conditions in which RuBP carboxylase starts working as RuBP oxygenate and normal photosynthesis does not occur.

69 The correct sequence of cell organelles during photorespiration is **[CBSE AIPMT 2012]**

(a) chloroplast-Golgi bodies-mitochondria
(b) chloroplast-rough endoplasmic reticulum- dictyosomes
(c) chloroplast–mitochondria –peroxisome
(d) chloroplast–vacuole–peroxisome

Ans. *(c)*

None of the option is correct. Photorespiration required three cell organelles in sequence of chloroplast, peroxisome and mitochondria.

Option (c) may be correct if be read as said sequence.

70 During photorespiration, the oxygen consuming reaction(s) occur in **[CBSE AIPMT 2006]**

(a) stroma of chloroplasts and peroxisomes
(b) grana of chloroplasts and peroxisomes
(c) stroma of chloroplasts
(d) stroma of chloroplasts and mitochondria

Ans. *(a)*

The first reaction of photorespiration occurs in stroma of chloroplast. In this reaction the RuBP (Ribulose 1-5 biphosphate) consumes one oxygen molecule in presence of enzyme RuBisCO.

In peroxisome the glycolate transferred from chloroplast takes up O_2 and formed the glyoxylate whereas, the H_2O_2 released as byproduct.

71 Which one of the following is wrong in relation to photorespiration? **[CBSE AIPMT 2003]**

(a) It is a characteristic of C_3-plants
(b) It occurs in chloroplasts
(c) It occurs in day time only
(d) It is a characteristic of C_4-plants

Ans. *(d)*

Dicker and **Tio** (1959) discovered photorespiration in tobacco plant. It is a light dependent process of oxygenation of Ribulose Bisphosphate (RuBP). During this process CO_2 is liberated and O_2 is consumed. C_4-plants avoid photorespiration by following Hatch Slack pathway.

72 Which enzyme is most abundantly found on earth? **[CBSE AIPMT 1999]**

(a) Catalase (b) RuBisCO
(c) Nitrogenase (d) Invertase

Ans. *(b)*

RuBisCO (RuBP carboxylase) is the most abundant protein on this planet. RuBisCO constitutes 16% of chloroplast protein. It is required for CO_2 fixation with RuBP (Ribulose Biphosphate) in Calvin cycle.

73 Photorespiration is favoured by **[CBSE AIPMT 1996]**

(a) high O_2 and low CO_2
(b) low light and high O_2
(c) low temperature and high O_2
(d) low O_2 and high CO_2

Ans. *(a)*

Photorespiration is light induced oxidation of photosynthetic intermediates with the help of oxygen. It is stimulated by high O_2 concentration or low CO_2, high light intensity, high temperature and ageing of leaf.

74 The substrate for photorespiration is **[CBSE AIPMT 1989]**

(a) ribulose bis-phosphate
(b) glycolate
(c) serine
(d) glycine

Ans. *(b)*

Photorespiration is the oxidation of photosynthetic intermediate without production of CO_2, ATP and $NADH_2$. The substrate for photorespiration is a 2-carbon compound glycolic acid (glycolate).

TOPIC 5
Factors Affecting Photosynthesis

75 With reference to factors affecting the rate of photosynthesis, which of the following statements is not correct? **[NEET 2017]**

(a) Light saturation for CO_2-fixation occurs at 10% of full sunlight
(b) Increasing atmospheric CO_2 concentration upto 0.05% can enhance CO_2-fixation rate

(c) C_3-plants respond to higher temperature with enhanced photosynthesis, while C_4-plants have much lower temperature optimum
(d) Tomato is a greenhouse crop, which can be grown in CO_2 enriched atmosphere for higher yield

Ans. *(c)*

In C_4-plants, the initial fixation of CO_2 occurs in mesophyll cells. The primary acceptor of CO_2 is Phosphoenol Pyruvate (PEP). It combines with CO_2 in the presence of enzyme PEP carboxylase to form the first stable product, i.e. Oxalo Acetic Acid (OAA). Where as C_3-plants lack $PEP_{carboxylase}$ enzyme. They possess RuBisCO enzyme. This enzyme can work as both carboxylase (fixation of CO_2) and oxygenase (fixation of O_2). RuBisCO has a much greater affinity for CO_2 than for O_2 and the binding is competitive. At higher temperature, its affinity for CO_2 decrease and it works as oxygenase.

Therefore, at higher temperature photosynthesis decrease in C_3-plants, while in C_4-plants it increases.

76 Emerson's enhancement effect and red drop have been instrumental in the discovery of **[NEET 2016, Phase I]**

(a) two photosystems operating simultaneously
(b) photophosphorylation and cyclic electron transport
(c) oxidative phosphorylation
(d) photophosphorylation and non-cyclic electron transport

Ans. *(a)*

Emerson performed photosynthetic experiment on *Chlorella*. He provided monochromatic light of more than 680 nm and observed decrease in rate of photosynthesis known as red drop.

Later, he provided synchronised light of 680 nm and 700 nm and observed increase in rate of photosynthesis, known as enhancement effect. This experiment led to discovery of two photosystems –PS-I and PS-II operating in photosynthesis.

77 The oxygen evolved during photosynthesis comes from water molecules. Which one of the following pairs of elements involved in this reaction? **[NEET 2016, Phase I]**

(a) Manganese and chlorine
(b) Manganese and potassium
(c) Magnesium and molybdenum
(d) Magnesium and chlorine

Ans. *(a)*

Photolysis of water during photosynthesis evolve nascent oxygen in the presence of manganese, calcium and chloride ions.

78 Plants adapted to low light intensity have **[CBSE AIPMT 2004]**

(a) larger photosynthetic unit size than the sun plants
(b) higher rate of CO_2 fixation than the sun plants
(c) more extended root system
(d) leaves modified to spines

Ans. *(a)*

Shade tolerant plants have lower photosynthetic rates and hence, lower growth rates. On the other hand, these plants have larger photosynthetic unit size than the sun plants.

79 The principle of limiting factors was proposed by **[CBSE AIPMT 1996]**

(a) Blackmann (b) Hill
(c) Arnon (d) Liebig

Ans. *(a)*

The principle of limiting factors was given by Blackmann, a British plant physiologist in 1905, according to him, light intensity, carbon dioxide concentration and temperature are the limiting factors in photosynthesis. 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.

80 Photosynthetically active radiation is represented by the range of wavelength **[CBSE AIPMT 1996, 2004, 05]**

(a) 340-450 nm (b) 400-700 nm
(c) 500-600 nm (d) 400-950 nm

Ans. *(b)*

Photosynthetically Active Region (PAR) of solar radiation is visible region. It consists of radiations having wavelength betwen 400 to 700 nm. Green plants use this wavelength in the process of manufacture of food, i.e. photosynthesis.

81 A photosynthesising plant is releasing ^{18}O more than the normal. The plant must have been supplied with **[CBSE AIPMT 1993]**

(a) O_3
(b) H_2O with ^{18}O
(c) CO_2 with ^{18}O
(d) $C_6H_{12}O_6$ with ^{18}O

Ans. *(b)*

Ruben, Hassid and Kamen (1941) using heavy isotope of oxygen, O^{18} in water, found that oxygen evolved in photosynthesis comes from water. Evolution of oxygen does not require carbon dioxide.

82 At a temperature above 35°C **[CBSE AIPMT 1992]**

(a) rate of photosynthesis will decline earlier than that of respiration
(b) rate of respiration will decline earlier than that of photosynthesis
(c) there is no fixed pattern
(d) both decline simultaneously

Ans. *(a)*

Optimum temperature for photosynthesis is 10°-25°C for C_3-plants and 30°-45°C for C_4-plants. Optimum temperature for respiration is 20°C–30°C, i.e. respiration has a higher temperature optimum than photosynthesis and thus declines later.

83 During monsoon, the rice crop of Eastern states of India shows lesser yield due to limiting factor of **[CBSE AIPMT 1991]**

(a) CO_2 (b) light
(c) temperature (d) water

Ans. *(b)*

According to the principle of limiting factor, the rate of the process is limited by the pace of the slowest factor. Light intensity varies with latitude, altitude, season, topography, presence or absence of interceptors like cloud, dust, fog, humidity, etc. In Eastern states, low light intensity during monsoon results in low photosynthesis and hence, lesser yield.