IMPORTANT QUESTIONS CLASS – 11 BIOLOGY CHAPTER -11 PHOTOSYNTHESIS IN HIGHER PLANTS

Question 1.
Give four important differences between photosynthesis and respiration.

Answer:

Photosynthesis	Respiration
1. Occurs only in green cells.	1. Occurs in all Living cells.
2. Occurs in chloroplasts in the cell.	2. Occurs in mitochondria.
3. Needs light to occur.	3. Does not need light.
4. Uses CO2 and water.	4. Uses glucose and oxygen releases CO_2 and water.
5. It ïs a constructive process.	5. It is a destructive process.

Question 2.
Explain the principle of limiting factor with a suitable graph.

Answer:
Law of limiting factor: When a chemical reaction is conditioned as to its rapidity by a number of separate factors then the rate of reaction is as rapid as the slowest factor permits.

As is clear that as the light intensity is increased the rate of photosynthesis increases proportionately until some other factor like CO, becomes limiting. Ultimately the plant becomes light-saturated indicating that light is no more the limiting factor. If now the cone, of CO, is increased the rate of photosynthesis increases until the light becomes a limiting factor.

Question 3.
(i) What does chlorophyll do to the light falling on it?

Answer:
Chlorophyll molecule becomes excited as soon as light falls on it. It was given out an electron acceptor which returns to release gradually energy in the form of ATP.

(ii) Which pigment system absorbs the red wavelength of light?

Answer:
Photosystem I.

Question 4.
Name the two main sets of reactions in photosynthesis in which light energy is required write down the reaction.

Answer:
(i) Photolysis for breaking down of water molecule.
energy

$$4\ H_2O \xrightleftharpoons{\text{energy}} 2H_2O + 4\ H^+ + 4\ e^-$$

(ii) Photophosphorylation for the conversion of light energy into chemical energy.
ADP + iP → ATP

Question 5.
What is photorespiration? Describe the process in detail and link it with the Calvin cycle.

Answer:
Enzyme Rubisco catalyzes the carboxylation reaction where CO_2 combines with RuBP. This enzyme catalyzes the combination of O_2 with RuBP called oxygenation. Respiration that is initiated in chloroplasts and occurs in light only is called photorespiration.

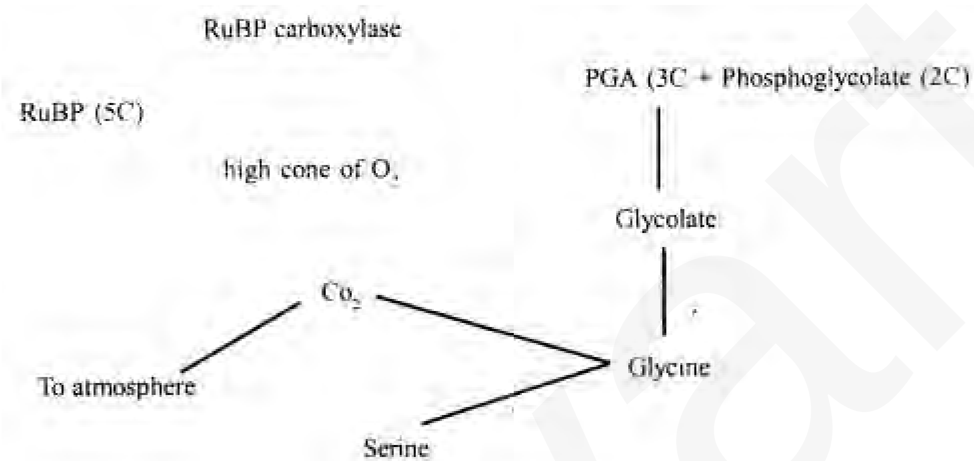
The oxygenation of RuBP in presence of O_2 is the first of photorespiration, which leads to the formation of one molecule of phosphoglycolate, a two-carbon compound, and one molecule of PGA. While PGA is used up in the Calvin cycle, the phosphoglycolate is dephosphorylated to form glycolate in the chloroplast and in turn diffused to peroxide, where it is oxidized to glyoxylate.

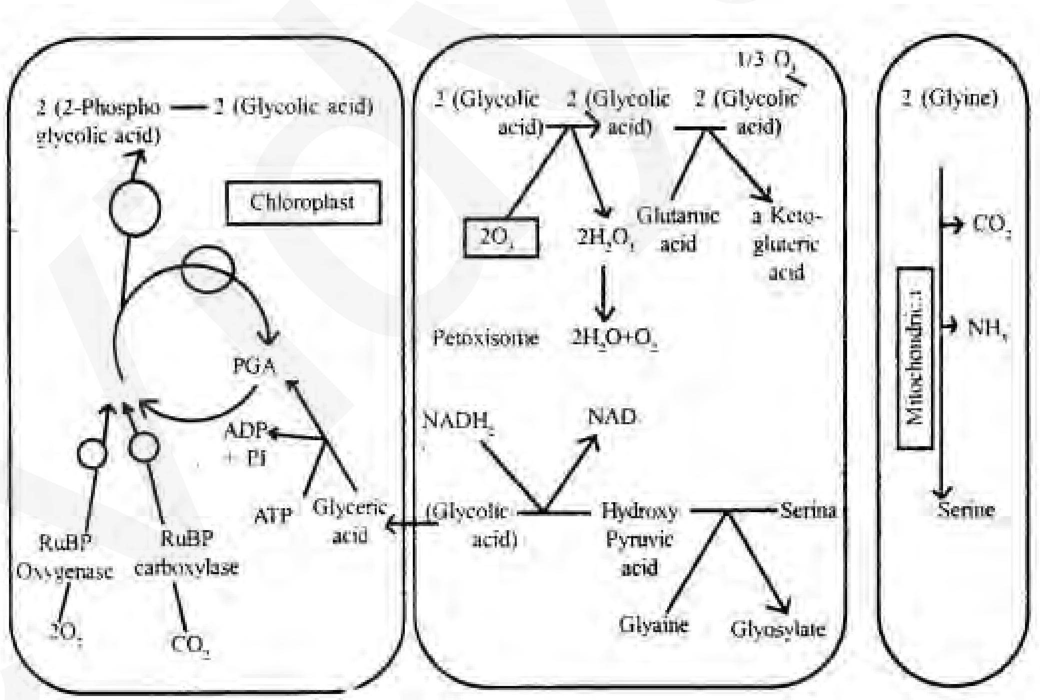
In the peroxide, the glyoxylate is used to form amino acid and glycine-calycine enters mitochondria where two glycine molecules (4 carbon) give rise to one molecule of serine (3 carbon) and one CO_2 (one carbon). The serine is taken up by peroxisome and converted into glycerate. The glycerate enters the chloroplast where it is phosphorylated to form PGA. PGA molecules enter the Calvin cycle to make carbohydrates releasing one molecule of CO_2 In mitochondria photorespiration is also called the photosynthetic carbon oxidation cycle.

Increased O_2 level increases photorespiration whereas increased CO_2 level increases photorespiration (and increases C_2 photosynthesis).

In C_3 plants photosynthesis occurs only in one cell type i.e. mesophyll cells. Both light reactions and carbon reactions occur in mesophyll cells in C_3 plants. In C_4 plant photosynthesis requires the presence of two types of photosynthesis cells that is mesophyll cells and bundle sheath cells. The C_4 plants contain dimorphic chloroplasts, which means chloroplasts in mesophyll cells are granular. Therefore C_2 pathway does not operate in the C_4 pathway.

All the important changes can be summarised as





Question 6.
Describe carbon reactions of the C_3 pathway. Does this pathway operate also in C_4 plants?

Answer:

The reactions catalyzing the assimilation of CO_2 to carbohydrates take place in the stroma where all the necessary enzymes are localized. These reactions are referred to as ‘carbon reactions’ (also called dark reactions) leading to the photosynthetic reduction of carbon to carbohydrates.

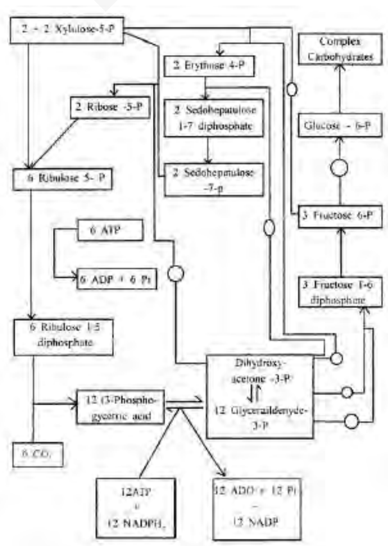
In the first phase of carbon reaction, Co2 enters the leaf through the stroma. This CO_2 is accepted by a 5-carbon molecule, ribulose-1-5 bisphosphate (RuBP) already present in the leaf. It forms two molecules of 3-carbon, compound, 3- phosphoglycerate (PGA). This 3-carbon molecule is the first stable product of this pathway and hence it is called C, PATHWAY.

The formation of (PGA) with CO_2 combining with RuBP is called carboxylation. This reaction is catalyzed by an enzyme called ribulose bisphosphate carboxylase (Rubisco). This enzyme also possesses oxygenase activity and hence abbreviated as Rubisco. This activity allows O, to compete with Co2 for combining with RuBP.

After the carboxylation reduction of PGA occurs and ATP and NADPH, formed during photochemical reactions with the reduction of PGA, glyceraldehyde-3 phosphate-a carbohydrate is formed. These 3-carbon molecules, also called triose phosphates act as precursors for the synthesis of sucrose and starch. To complete the cycle, and to continue it, regeneration of the 5-carbon acceptor molecule, that is RuBP takes place.

The C_3 type of carbon reaction occurs in the stroma of the chloroplast. This pathway is called the Calvin cycle.

The CO_2concentrating mechanism is called the C_4 pathway. Operation of the C_4 pathway requires the cooperation of both cell-type mesophyll and bundle sheath cells. The objective of the C. pathway is to build up a high concentration of CO_2 which suppresses photorespiration. This C. pathway is more efficient than the C_3 pathway. Hence C? pathway does not operate C_4 plants. (See the table)

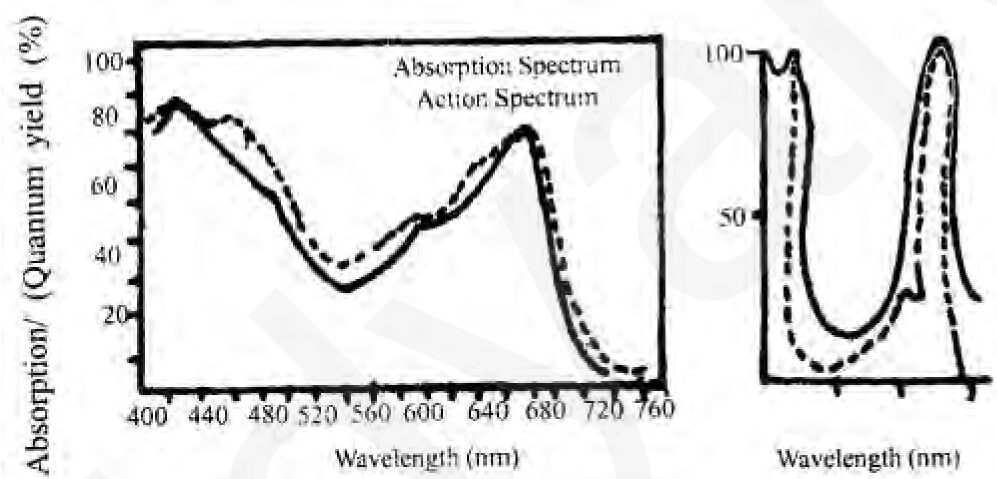


Schematic representation of C_3 pathway Calvin cycle.

Question 7.
Describe briefly the experiment conducted by the scientist, T.W. Englemann.

Answer:
T.W. Englemann plotted the action spectrum of photosynthesis.

Photosynthesis can occur in visible light of wavelength varying between 390 to 763 nm. The rate of photosynthesis is not uniform in light of all wavelengths.
It varies depending upon their relative absorption by chlorophyll pigments. The graph showing the relative yield or rate of photosynthesis in plants exposed to monochromic light of different wavelengths is termed as ACTION SPECTRUM. The rate of photosynthesis, as shown in the action spectrum is maximum in the blue region of light.



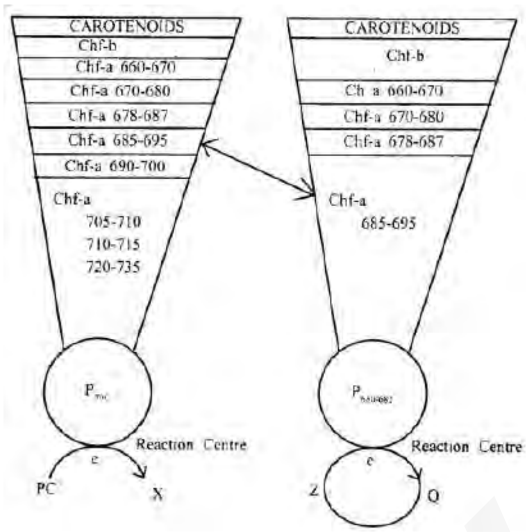
Curves showing a comparison of absorption and action spectra of chlorophyll pigments during photosynthesis

Question 8.
What is a photosystem? Which is the pigment that acts as a reaction center? Describe the interaction of photosystem 1 and photosystem II.

Answer:
The light is entrapped by a group of chlorophyll molecules which together constitute a photosystem. Each pigment system has a trap or reaction center, which is either P_{700} or P_{680} ao. In this 'P' stands for pigment and figures 680 and 700 for the wavelength of light. Chlorophyll molecule acts as a trap center with the transfer of high energy electron to electron transport system (ETS).
The high-energy electrons return rapidly to their normal low energy orbitals in the absence of light and the excited chlorophyll molecule reverts to its original stable condition. These two photosystems: photosystem-I and photosystem-11 exist with different forms of

chlorophyll 'a' as the reaction center. The PS-II is located in the appressed regions of grana thylakoids and the PS-I in the stroma thylakoids and non-appressed regions of grana.

The function of two photosystems that interact with each other is to trap light energy and convert it to chemical energy (ATP). This chemical energy stored in the form of ATP is used by living cells.



Distribution of pigment in photosystem I and Photosystem II.

Question 9.
What led to the evolution of the C_4 pathway of photosynthesis? Describe in detail.

Answer:
Kortschak (1965) observed that in sugarcane, the compound in which CO, got incorporated was oxaloacetic acid or oxaloacetate (OAA), a 4-carbon compound instead of phosphoglyceric acid, a 3-carbon com¬pound.

Hatch and Slack (1965-1967) found it a regular mode of CO_2 fIxation in a number of monocots such as sugar cane, maize, sorghum, and Pennisetum. They found that the initial acceptor of CO_2 in such plants is Phosphoenalpymvic acid instead of RuBP and the first stable compound is oxaloacetate acid, a 4-carbon compound. These plants are termed C_4 plants as the first stable compound is a 4-carbon compound and other plants are termed C_3 plants.
Hatch and Slack observed that these plants have another pathway of CO_2 a fixation that precedes the Calvin cycle occurring in C_3 plants. This cycle is known as the C_4 pathway.

Question 10.
Describe in detail how ATP and NADPH2 are formed during photochemical reactions?

Answer:
Photosynthesis at present is thus considered basically an oxidation-reduction process during which water is oxidized to release oxygen and CO_2 is reduced to carbohydrates.
Photosynthesis involves two steps- the first step is light-dependent called Light reaction or Hill reaction or photochemical phase. The second step is the Dark reaction or Blankman's reaction or the Biosynthetic phase, which does require light.

Light Reaction or Hill Reaction: During this process, solar energy is converted into chemical energy, light is trapped by chlorophyll and carotenoid pigments and is converted into chemical energy which is stored in the form of ATP energy-rich molecule.
Photolysis of water occurs that leads to the evolution of oxygen and formation of H^+ ions, the latter combining with NADP to form $NADPH_2$ often termed as reducing power. ATP and NADPH together termed assimilatory power as CO_2 fixation during the dark reaction.

Photolysis of water takes place in presence of light and water oxidizing enzyme as follow:

$$4\,H_2O \xrightarrow[\text{water oxidising enzyme}]{\text{light}} 4H^+ \; 4OH$$

The unstable OH" combines to form
water and molecular oxygen after
losing the electrons which are accepted
by oxidized chlorophyll molecule.
(P_{680} of PS_{11}) through an unknown electron acceptor compound "Z". This step requires the presence of Mn^{++} and Cl' ions.

$$4OH \xrightarrow{Mn^{++},\; Cl} 4e + 2H_2O + O_2$$

$$4\,Chl^+ \; 4e^- \xrightarrow{\text{"Z"}} 4Chl$$