BCH 202-GENERAL BIOCHEMISTRY 11

DR AKINLOYE'S ASPECT- PHOTOSYNTHESIS

PHOTOSYNTHESIS -: This is the process by which photosynthetic organism harness radiant energy and convert it to useful forms of chemical energy basically to sustain not only their own existence but also the existence all aerobic non-photosynthetic organism. The net equation involving the chemistry of photosynthesis is summarized thus:

$6CO_2 + 6H_2O + \text{SOLAR ENERGY} \longrightarrow C_6H_{12}O_6 + 6O_2$

This process is also often referred to as carbon cycle and is responsible for the continuous existence of life. The specialized organelle where photosynthetic chemical reactions occur is called the chloroplast. The chemical event that occur in photosynthesis is in two distinctive phases namely

I. Light reaction
II. Dark reaction

Note that light reaction is dependent on an input of radiant energy and involves four processes/stages.

I. Photochemical excitation of chlorophyll
II. Oxidative cleavage of water (photooxidation)
III. Formation of NADPH (photoreduction)
IV. Formation of ATP (photophosphorylation)

The dark reaction involves the enzymatic assimilation and conversion of CO_2 to CHO. Note that the NADPH and ATP formed in the light reaction as sources of reducing power and energy respectively i.e

$$CO_2 \xrightarrow[ATP]{NADPH_2} (CH_2O)_n$$

LIGHT REACTION OF PHOTOSYNTHESIS

The primary photochemical event that happens is the absorption of photons of light by chlorophyll molecule which results in their excitation to higher energy levels. Thereafter, electrons from the excited chlorophyll molecules are transferred to specialized acceptor molecule and ultimately to $NADP^+$ which is accompanied by ATP formation. Water serves as e^- donor (reducing agent) purposely to return the electron deficient (oxidized chlorophyll) molecule back to the ground state in a process accompanied by the release of oxygen molecules.

The net reaction is given is given thus:

Note -: light dependent phase of photosynthesis include two separate photosystems both of which must be activated for maximum efficiency. These photosystems are photosystem 1 or PS 1 or P_{700} (which contain largely chlorophyll a and photosystem 11 or PS 11 or P_{680} which contain both chlorophyll a and chlorophyll b.

ELECTRON TRANSPORT CHAIN IN PHOTOSYNTHESIS

The electron flow in the dual photosystem model of the light reaction could be by:

I. Non-cyclic phosphorylation
II. Cyclic phosphorylation

In non-cyclic phosphorylation, the electron flow from one photosystem is associated with ATP production while the electron flow from the other is associated with NADPH production. However, the conventional and normal mode of operation is non-cyclic flow, though the chlorophyll can shift to cyclic mechanism under certain conditions. The processes of non-cyclic phosphorylation are considered in three segments thus:

a) PS 11 -: It involves the production of oxygen. No intermediate is involved. It is assumed that photooxidation of water occur to give O_2 and H^+.
b) PS 11 to P_{700}-: Electrons from photosystem 11 enters the pathway reminiscent of that in mitochondria. At least one molecule of plastoquinone and oxidized P_{700}, there exist at least three different electron carriers namely cytochrome b, which is an iron-sulphur (Fe-S) protein, cyt-f and plastocyanin with one atom of copper (Cu).
c) REDUCTION OF $NADP^+$ -: The intermediate electron acceptor from P_{700} is chlorophyll a, which passes the electron to membrane bound (FeS) protein, then to $(FeS)_2$ ferredoxins. Finally, electron flow via flavoprotein to $NADP^+$.

There exist some similarities between the processes of oxidative phosphorylation and photophosphorylation and these are;

1. Oligomycin anf phlorhizin are inhibitor of both electron and phosphorylation
2. Antimycin A blocks the oxidation of b-type cytochrome
3. The same lipophylic phenols (e.g 2,4-dinitrophenol) acts as an uncoupler.
4. All inhibitors of electron transport prevents phosphorylation.
5. Both processes depend upon the integrity of the membrane

The flow of electrons in the photosystem model of light reaction is shown below

DARK REACTION (FIXATION OF CO_2)

The dark reaction is summarized by this equation

The conversion of CO_2 to simple sugar is through Calvin Cycle. The first reaction of this cycle is the conversion of ribulose-1,5-bisphosphate to two molecules of 3-phosphoglyrate molecules and it is catalyzed by the enzyme ribulose-1,5-phosphocarboxylase (RUBISCO)

The synthesis of hexose sugar from 3PG is achieved by the concerted actions of enzymes of glycolysis and those of pentose phosphate pathway as summarized by Calvin-Benson_Bassham Scheme shown below.

NET REACTION:

The reaction is regulated by the action of RUBISCO whose activity is inhibited by fructose-1,6-bisphosphate and activated by fructose-6-phosphate.

After the formation of fructose-6-phosphate, it is converted to starch follow the re action sequence below: