BCH 413- PLANT BIOCHEMISTRY (2 UNITS)

- ORGANIZATION OF PLANT CELLS
- PHOTOSYNTHESIS
- ALKALOID
- PLANT HORMONES
- BIOSYNTHESIS OF PLANT CAROTENOID
- BIOCHEMISTRY OF PLANT DEVELOPMENT
- STRUCTURES, FUNCTIONS AND RELATIONSHIP OF PLANT GROWTH REGULATORS
- HERBICIDES

ORGANIZATION OF PLANT CELLS -: refer to Bio 101. Taking notes of organelles such as cell wall, chloroplast, mitochondria, ribosome e.t.c and their respective functions.

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

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

LIGHT REACTION OF PHOTOSYNTHESIS.

Not all wavelengths of light are absorbed during photosynthesis. Green, the color of most plants, is actually the color that is reflected. The light that is absorbed splits water into hydrogen and oxygen:

H_2O + light energy ---> ½ O_2 + $2H^+$ + 2 electrons

1. Excited electrons from Photosystem I can use an electron transport chain to reduce oxidized P_{700}. This sets up a proton gradient, which can generate ATP. The end result of this looping electron flow, called cyclic phosphorylation, is the generation of ATP and P_{700}.
2. Excited electrons from Photosystem I could flow down a different electron transport chain to produce NADPH, which is used to synthesize carbohydratyes. This is a noncyclic pathway in which P_{700} is reduced by an exicted electron from Photosystem II.
3. An excited electron from Photosystem II flows down an electron transport chain from excited P_{680} to the oxidized form of P_{700}, creating a proton gradient between the stroma and thylakoids that generates ATP. The net result of this reaction is called noncyclic photophosphorylation.
4. Water contributes the electron that is needed to regenerate the reduced P_{680}. The reduction of each molecule of $NADP^+$ to NADPH uses two electrons and requires four photons. Two molecules of ATP are formed.

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:

fructose-6-phosphate

↓

glucose-6-phosphate

↓

ADP-glucose

↓

↓

Starch/sucrose

Here is a summary of the steps used by plants and other organisms to use solar energy to make chemical energy:

1. In plants, photosynthesis usually occurs in the leaves. This is where plants can get the raw materials for photosynthesis all in one convenient location. Carbon dioxide and oxygen enter/exit the leaves through pores called stomata. Water is delivered to the leaves from the roots through a vascular system. The chlorophyll in the chloroplasts inside leaf cells absorbs sunlight.
2. The process of photosynthesis is divided into two main parts: light dependent reactions and light independent or dark reactions. The light dependent reaction happens when solar energy is captured to make a molecule called ATP (adenosine triphosphate). The dark reaction happens when the ATP is used to make glucose (the Calvin Cycle).
3. Chlorophyll and other carotenoids form what are called antenna complexes. Antenna complexes transfer light energy to one of two types of photochemical reaction centers: P_{700}, which is part of Photosystem I, or P_{680}, which is part of Photosystem II. The photochemical reaction centers are located on the thylakoid membrane of the chloroplast. Excited electrons are transferred to electron acceptors, leaving the reaction center in an oxidized state.
4. The light-independent reactions produce carbohydrates by using ATP and NADPH that was formed from the light-dependent reactions.

FLAVONOID AND ALKALOID

Flavonoids and their derivatives are examples of natural pigments which are examples of natural pigments which are responsile for the colour of a number of foods and food products/materials. They have the basic structure shown below

Among the pigment derived from these structures are

I. Anthocyanins
II. Flavonones
III. Flavanol

IV. Flavones

It is the extent of delocalization of the electrons of central heterocyclic ring that is responsible for the different colours of anthocyanins (red or violet).

In food biochemistry, about six forms of anthocyanins are important and these has OH group on the 3,5,7 carbon while of the OH or methoxyl on 3^{I}, 4^{I} and 5^{I} carbons of the ring confers the difference.

The anthocyanins are often linked to one or several sugars and this often confer pigment changes as well as different function on them.

Certain flavonoids, such as leucocyanidins are colourless, however during oxidation processes, these colourless compounds undergo transformation into anthocyanidins (red or pink). This exemplifies what happen in certain varieties of apples, pears or bean. Moreso, the bitter taste of some grape fruits, lemon or oranges are due to the presence of flavonones such as naringin and hesperidin.

IMPORTANCE OF FLAVONOIDS IN FOOD TECHNOLOGY

1) Flavonol glycosides representing about 30% of the dry extract in tea contributes to astringent quality.
2) A non-bitter compound,naringenin may be obtained from naringin (bitter) by treating it with α -L-rhamnosidase and β -glucosidase in a process known as debitterization of narigin.
3) α-L-rhamnosidase is also known to react with hesperidin to yield dehydrochalonehesperidin glucoside, which is a sweet tasting substance often used as sweetner.

It should be noted that it is important to control the Ph, temperature and conditions supporting oxidation during storage so as to minimize or prevent reaction(s) which may give rise to colorless compound, because this is undesirable for the fruits and vegetable industries.

BIOLOGICAL AND PHARMACOLOGICAL PROPERTIES OF FLAVONOID

One of the functions of flavonoid in plant is to protect them against disease caused by microorganism and also to act as feeding deterrent to insects and other herbivores animals by providing toxic substances, thereby inhibiting the growth of microorganism or give unpleasant sensation to the taste buds of animals. Some isonvertin from the uvana roots (*Annonaceae*) have been reported to possess antimicrobial and cytotoxic property.

- Also, taxifolin, derivative of dihydroflavonol exhibits significant anti-inflammatory activity similar to that of hydrocortisome
- Furthermore, dihydroquarcetin (flavonol) has been shown to possess antiviral activities

- Naphtoquinone which are found in flowers and mushrooms are used as colouring or purgative
- Dicoumarol is known to be used in prevention of blood clotting.

OTHER IMPORTANT DRUGS/CHEMICALS THAT COULD BE DERIVED FROM PLANTS ARE LISTED BELOW