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PHOTOSYNTHESIS:

Etymology:

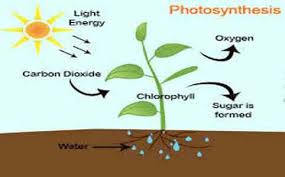
**Photo synthesis is basically a greek word; photo means light and synthesis means to put something together so photsynthesis gives meaning as to put something together in prescence of light**

**DEFINITION:**

**“carbohydrates formation** from carbon dioxide and a source of hydrogen (such as water) in the chlorophyll-containing cells (as of green plants) exposed to light”

**OR**

“the complex process in which CO2, H2O, and certain inorganic salts are converted into carbohydrates by plants, algae, and certain bacteria, by the action of sunlight caused by chlorophyll”



General view of photosynthesis:

Almost all Earth’s life depends on that food made by such organisms which can capable of doing photosynthesis these are green plants, algae, and cyanobacteria. These organisms by using CO2 and H2O in presence of sunlight help in formation of carbohydrates. By using chlorophyll they capture light of different frequencies such as chlorophyll a mainly absorbs blue and red frequency light and reflect green light that’s why plant appears to be green. Chlorophyll and carotenoids are other accessory pigments in photosynthesis*.* Green color usually dominates the effect of carotenoids but it can be seen in autumn season when red and yellow colors appears due to fall of chlorophyll. In photosynthesis these accessory pigments absorb energy and this energy is passed to chlorophyll a. which proceed to the next step light reaction and in this light reaction uses this energy to break water molecule to gets electron an leaving oxygen and hydrogen ions thus oxygen formation during light reaction is released as waste becausei ts production is more than its use in cellular respiration. Today all of the atmospheric oxygen is produced as waste from photosynthesis ,and cyanobacteria producing since three billion years ago, since their first appearance in the Precambrian Eon.Carbohydrates is formed by carbondioxide by using hydrogen ions and electrons. Photosynthesis takes place in green parts of plants mostly where chlorophyll is in abudance. photosynthesis takes place in chloroplast in which chlorophyll is present, these chloroplasts present in in cells of parenchyma and in column like cells of palisade layers. Stomata allow the air which contain carbon dioxide into leaves. Stomata also allows oxygen to leave. Water is obtained by roots of the plants and conveyed by vascular root system “xylem”. Carbohydrates that is formed by plants is transported through “phloem .

Photosynthesis may occur in different organisms but the common thing is that the reaction always proceed with reaction centers and chlorophyll a is present in reaction centers. In plants, proteins are held in organelles which is called chloroplast, most abundant in leaf cells. In bacteria, these proteins are submerged in plasma membrane. In the light reaction ,some energy is used to stripe electrons from water to produce oxygen. The hydrogen ion that is being freed by splitting water molecules , help in formation of compounds that serves as short term stores of enregy, those compounds are being reduced into NADH & ATP.

Long term shortage of sugars, carbohydrates in plants , algae photosynthetic bacteria is due to subsequent sequence of light dependent reaction called as calvin cycle, some bacteria also used different mechanism called as reverse kreb cycle to attain same result. In calvin cycle carbon dioxide that is obtained from atmosphere , that carbon dioxide is incorporated in existing organic molecules such as RIBULOSE BIPHOSPHATE using ATP and NADPH which is being produced in light dependent reactions , resulting compounds are being reduced and removed to form carbohydrates(glucose & sucrose etc)

In evolutionary history first organism performed photosynthesis evolved and most probably use hydrogen or hydrogen sulphide , instead of water(source of water). The oxygen of air is contribution of cyanobacteria, but it appeared later. Abundancy of air due to cyanobacteria leads to complex process of life.

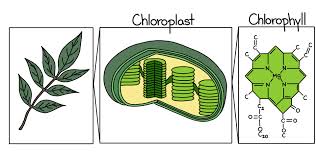
Some photosynthetic organisms are called as photoautotrophs which means they can synthesize their food directly using carbon dioxide and water. But some organisms cannot use carbon dioxide directly as photoautotrophs do, rather they use organic material for sake of carbon dioxide, such type of organisms re called as photoheterotrophs.

GENRAL EQUATION FOR PHOTOSYNTHES:

CO2(carbon  
dioxide) + 2H2Owater + photon (sunlight energy) → [CH2O]carbohydrate + O2(oxygen) + H2O(water)n

In photosynthetic bacteria protein gathering light for the process of photosynthesis are embedded in cell membranes of bacteria. The membrane may be folded tightly into cylindrical sheets called as thylakoids ,or pilled up into vesicles called as intracytoplasmic membranes. Those thylakoids and intra cytoplasmic membranes can fill almost cell’s interior , increasing the surface area of the cell and increasing the absorbed amount of light

Chloroplast:As photosynthesis takes place in chloroplasts, so generally a plant cell contain about 10 to 100 chloroplasts in plants. The chlorophyll is enclosed by inner and outer membrane which contain intermembrane space between them. membrane is formed of phospholipids(both inner and outer) . there is aqueous fluid present inside the inner membrane called as stroma. In the stroma grana are embedded, grana is plural of grana and each grana is stack of 50 thylakoids, and basically these grana(thylakoids) are site of photosynthesis. Thylakoids are flattened discs and composed of thylakoid membrane ,which encloses thylakoid space(lumen). In the thylakoid membrane essential protein complexes of photosynthetic systems are present.



Pigments:

Plant usually absorb ligh by using pigment chlorophyll. The green color of light is not absorbed by chlorophyll and reflected so that’s the reason plants appear to be green. Xanthophylls are also used by plants to absorb light spectrum. Algae can also use chlorophyll but algae also have many other pigments such as phycocyanin in red algea, fucoxanthin in brown algae and likewise gives variety of different colours to plants.

Those pigments discussed above are embedded in complexes called as antenna protiens in reaction centers. In such way, pigmebts are allowed to worked together, such combination of protiens called as light harvesting complex. As all of us know that green parts of plants have chloroplasts, majority of the chloroplasts are found in leaves. The interior tissue of leaf having cells contain 450000 to 80000 chloroplast for every square millimeter of leaf . excessive evaporation of water and decreased absorption of UV or blue light is being protected by coating of waxy cuticle over the leaf. The area where the most photosynthesis appears palisade . mesophylls cells, here epidermis allows water to pass.

Stages of photosynthesis:

* Light dependent reactions
* Light independent reactions

LIGHT DEPENDENT REACTION

Light reactiontakes place in presence of light ,its also called as **photochemical reaction or Hill reaction .** in this light reaction light is being absorbed by chlorophyll and rich energy compounds ATP and NADPH formed. Photosynthesis may occur in different organisms but the common thing is that the reaction always proceed with reaction centers and chlorophyll a is present in reaction centers. In plants, proteins are held in organelles which is called chloroplast, most abundant in leaf cells. In bacteria, these proteins are submerged in plasma membrane. In the light reaction ,some energy is used to stripe electrons from water to produce oxygen. The hydrogen ion that is being freed by splitting water molecules , help in formation of compounds that serves as short term stores of enregy, those compounds are being reduced into NADH & ATP. In plants, proteins are held in organelles which is called chloroplast, most abundant in leaf cells. In bacteria, these proteins are submerged in plasma membrane. In the light reaction ,some energy is used to stripe electrons from water to produce oxygen. The hydrogen ion that is being freed by splitting water molecules , help in formation of compounds that serves as short term stores of enregy, those compounds are being reduced into NADH & ATP.

There are three steps of light dependent reaction these are:

* **Electron transport and phosphorylation**
* **Phototysis of water**
* **Reduction of NADP to form NADPH2**

1. Electron transport and photophosphorylation:

Basically electron transport chain is series of complexes and photosystem I & II which transfer electron from splition of water to various complexes and in the end result in production of ATP & NADPH

**“Formation of ATP , as a result of special processes is known as Phosphorylation**.”

Thr pathway to which phosphorylation occur is electron transport chain. light reaction occur in chloroplast’s thylakoid membrane where chlorophyll present to capture sunlight. Basically two systems are involved in the electron transport hain , these are photosystem I and photosystem II. Various protien complexes are also pesent in electron transport chain such as plastoquinone, cytochrome, plastocyanin, ferredoxin,NADP reductase .

Photosynthetic pigments like chlorophyll a, b , carotenoids light absorbing pigments present in thylakoid membrane of the chloroplasts. So these pigments are incorporated with the special protien complexes these pigments along with complexes called as **photosystems**. Each photosystem have light harvesting complexes which comprises of mainly chlorophylls and less likely other pigments. When spectrum of light is being fall on photosystem its electrons get excited which means that electrons move to high energy state from normal.

There are two photosystems in ETC which are

* Photosystem I
* Photosystem II

Photosystem II comes prior to Photosystem II. photosystem absorb light best at 680nm. The primary acceptor of the photosysytem II is pheophytin. Pheophytin is a mloecul that has resemblance with chlorophyll. Source of electrons of photosystem II is spiliting of water molecule which releases electron. Electron exicted in photosystem II is passed down to photosystem I.

PHOTOSYSTEM I comes later to photosystem II. this photosystem absorb light at 700nm. The primary acceptor of this photosystem is a chlorophyll called as A078 .Tthe electrons that is flowed from photosystem II is source of electrons for photosystem I.

There are two types of photophophorylation,

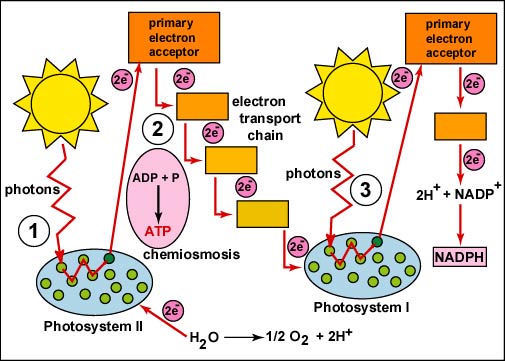
* Cyclic photophophorylation
* Non-cyclic photophosphorylation

**Non-cyclic phosphorylation**:

In non-cyclicphosphorylation , the process in which electron that is excited by photon from reaction center doesnot return to its original position. This noncyclic phosphorylation completed out dueto collaboration of both photosystems in non cyclic phosphorylation end product is both ATP & NADPH. Water supply is necessary for this reaction. Major steps are:

1. chlorophyll b of the reaction centre absorb light of 680nm and get activated, releasing an electron. Electron get excited to the energy level of high state . this excited electron is then transferred to primary electron acceptor that is **phaelophtin.**
2. From the primary electron acceptor electron is being sent to protein complex, **Plastoquinone(PQ**) and this complex is associated withFe ions.
3. Then plastoquinone convey this electron to another complex which is **cytochrome complex**. (cytochrome F and cytochrome b6.)
4. From cytochrome complex electron is being conveyed to another protein complex, **plastocyanin.** Plastocyanin is a reduced protein and is present in lumen, it is associated with copper.
5. From cytochrome F to b6 ATP formation occur
6. Plastocyanin conveys electron to PS I , here chlorophyll a present in reaction center, which absorb light at 700nm.
7. The photosystem absorb light energy and electron get excited, which is accepted by primary electron acceptor of photosystem I. the previous coming electron from first photosystem occupy space of this leaving electron.
8. Then electron is sent to **Ferredoxin reducing substrate,** its primary acceptor of this system
9. From prmary acceptor electron is delivered to **Ferredoxin** . it is iron containing protein.
10. From ferredoxin electron is conveyed to NADP where NADP reductase reduces NADP to NADPH.

AS a result ATP & NADPH are final products formed in this non cyclic phosphorylation.



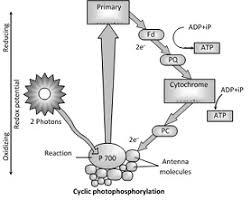
(Non-cyclic phosphorylation in which two photosystems are involved, electrons that get excited from reaction center passes to various protein complexes and then production of ATP and NADPH occur)

Cyclic-phosphorylation:

“**In some cases electrons do come back to their original position when get excited by photons and combination with various complexes”**

It is regarded as formation of ATP solely by photosystem I. this system can be found in photosynthetic bacteria. This type of photophosphorylation occurs on the stroma lamella. In cyclic photophosphorylation, from P700 of PS1 high energy electrons comes down in a cyclic pathway. In cyclic electron flow, the electron excited in a pigment complex called photosystem I, passes from the primary acceptor that is ferredoxin reducing substrate, to ferredoxin and then to plastoquinone, then flows to cytochrome b6f , and then flows to plastocyanin before returning back to Photosystem-1. This electron transport chain motivates a proton-motive force, that pumps H+ ions across the membrane; producing a concentration gradient used to power ATP synthase during chemiosmosis. This pattern is called as cyclic photophosphorylation, and it doesnot form O2 and NADPH. In cyclic photophosphorylation, NADP+ does not accept the electrons; they move back to cytochrome.This single photosystem is used by bacteria for photosynthesis, and therefore perform cyclic photophosphorylation. It is favorable during anaerobic condition.

When electron is being released by chlorophyll from photosystem I, it meets ferredoxin and then reaches cytochrome f. from this to cytochrome b6. At this spot one ATP molecule formation occurs. After that it is transferred to plastocyanin, from which it reaches back to chlorophyll a,this whole cycle is called as cyclic phosphorylation



(Cyclic phosphorylation in which there is only involvement of only one photosystem and then excited electrons passes to various complexes of proteins an formation of only ATP occurs, this also happens when there is shortage of ATP)

**Photolysis of water:**

The photolysis of water (H2O) in the ligh dependent reactions of photosynthesis is splitting of water which produced electron used to fill up the space, formed as a result of excitation of photosystem II in chloroplasts. Following equation describes splitting of water:

H2O → 2H+ + 2e- + 1/2O2

Oxygen is flowed out from plant to outer atmosphere as a waste product in light reaction.

Electrons are going to replace those place where photoexcitation from chlorophyll a in the reaction center of photosystem II occurs, and electrons excited from chlorophyll help in formation of ATP and reduction of NADP to NADPH.

**Reduction of NADP compound:**

**What is NADPH**  ? **How ATP is being reduced**?

NADP+ Produce NADPH . Ferredoxin NADP reductase present after photosystem I, That become the major source of NADPH in plants algae and cyanobacteria etc. basically it appears in last stage o f ETC of light reaction in photosynthesis. It may be used as reducing power in calvin cycle for assimilation of carbon dioxide into glucose . it has ability to accept electron in other non photosynthetic pathways as well i.e it is needed in reduction of nitrate into ammonia that is necessary for plant and to maintain nitrogen cycle.

**Reduction of NADP into NADPH**:

When splitting of water occurs, electrons, hydrogen ions and oxygen form. The hydrogen which gets seprated from water combines with a compound NADP to form NADPH . SO this way reduction take places. Hydrogen that is being attached with NADP, remain attached for a short period till it perform its function in dark reaction to form carbohydrates.

**NADP + H2 → NADPH2**

**NADP + 2H → NADPH + H**

**ssSo in this way light reaction of the photosynthesis occur, and net result is formation of 12 molecules of NADPH +H . 18 molecules of ATP and 6 molecules of oxygen which are released in atmosphere. During light reaction H+ ions get accumulated in thylakoid membrane, when these ions dffuse across thylakoid membrane into stroma, that released energy is used in production of ATP.**

**☺**