Long Answer Type Questions

Q. 1. Explain Van Niel experiment on purple and green sulphur bacteria.

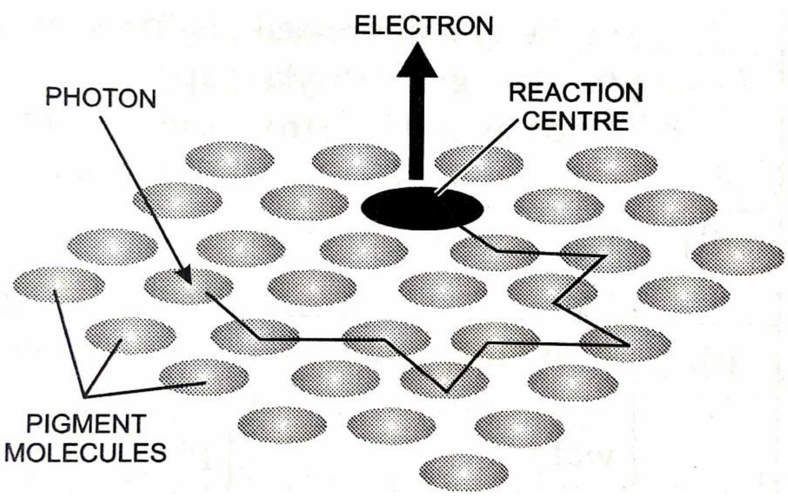
Ans. Van Niel on his studies with purple and green sulphur bacteria doemonstrated that photosynthesis is a light dependent reaction in which hydrogen from an oxidisable compound reduces CO_2 to form sugar.

$$2H_2A + CO_2 \xrightarrow{light} 2A + CH_2O$$

In Green plants, HO is the hydrogen donor and is oxidised to O_2 In green sulphur bacteria, when H_2O instead of HO was used as hydrogen donor no O_2 was evolved. He inferred that O_2 evolved by green plants come from H_2O but not from CO_2

Q. 2. Explain the photochemical phase of photosyn-thesis. What is the light reaction product. [KVS Agra 2016]

Ans. The photochemical phase : this phase of involve all those events which require sunlight. A photon absorbed by the molecules of the trapping or harvesting aone of P'S Iand PS II pass their energy to their respective reacion centre.

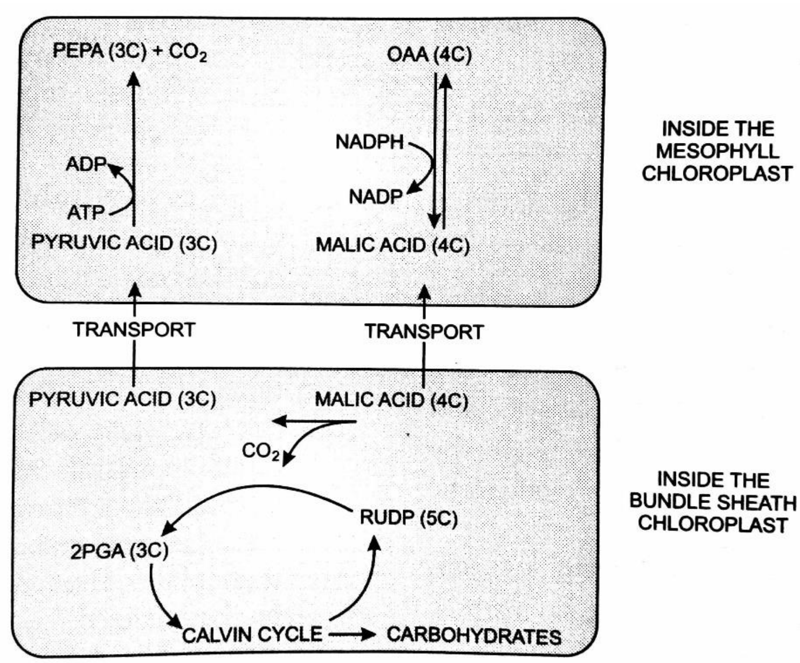


For pigment system 1 the light energy is gathered by cholorphyill a, and posibly by chlerophyll b, while for PS II ight energy is gathered by chlorophyll a, chlorophyll b and phycobillins.

Arnon et al (1954) discovered that in addition to carrying out Hill reaction the choloroplast also synthesize ATP in presence of light from ADP and inorganic phosphate. This process is called as photophosphorylation.

Q. 3. Under high concentration of O_2 RuBP binds with O_2 and forms one molecule of phosphoglycerate and phosphoglycolate.

Ans.



The malic acid releaies CO_2 which is transferred to bundle sheath cells where it i fixed through Calvin cycle The C_4 plants have a characteristic Kranz anatomy of leaf. There is no photorespiration in these plants.

Q.4 Where does cyclic pholophosphorylation accur? Describe the process. Why is the process referred to as cyclic ?

OR

Describe cydlic photophosphorylation. What is the purpose of proton gradient created during the process in the thylakoids ?

Ans. Cyclic photophosphorylation: **(i)** It occurs in the grana of chloroplast.

(i) What is this process called ?

(ii) Why is this process called a wasteful process ?

(iii) Briefly esplain the pathway by which plante ennure that the RuBisCO functions as a carboxylase, minimising the oxygenase activity.

[KVS Mumbai2016]

Ans. (i) Photorespiration

(ii) Photorespiration is called wasteful prosess becouse:

(a) No energy is produced in this process.

(b) Oxygen is consumed for nothing.

(c) $H_2 O_2$ is produced which is highly toxic

(d) The yield of photosynthesis įs reduced to 50%.

(iii) In C_4 plants eg, maize, sugar cane, grasses etc. light reaction occur in mesophyll cells and RuBlisCO is found in bundle sheath cell, in which CO_2 fixation occurs. Thus, in C_4, ptants RuBisCO remains protected from sunlight and is also protected from creygeniation, because in bundle sheath cells only dark reactions occurs.
In these plants the phosphoenol pyruvaty (PEP), a 3-carbon compound acts as CO_2 acceptor The PEP combines with CO_2 to form a 4-carbon compound oxaloscetric acid (OAA) which is soom converted into malic acid, a 4-carbon compound0

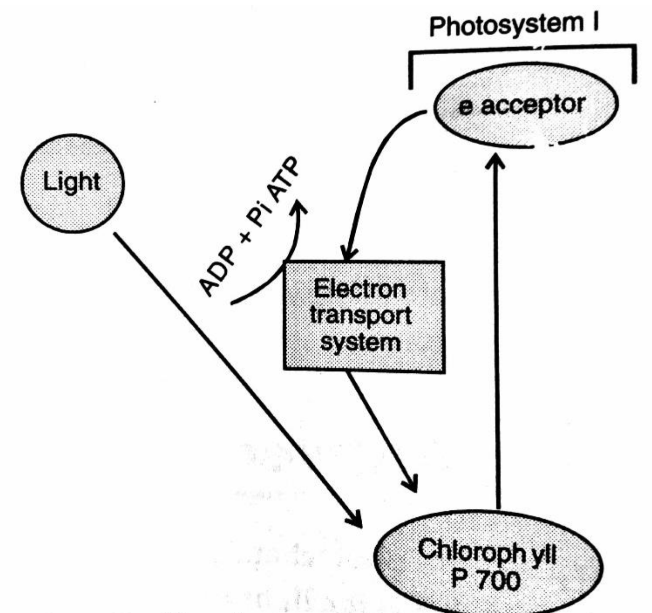


Fig. : Cyclic photophosphorylation

(ii) The process starts with the ejection of electron from P_{700} which ultimately accepts the same electron after travelling downhill through a series of electron acceptors.

(iii) During travel of electron through the electron acceptons, ATP is formed and hence the process is know as cyclic photophosphorylation.

(iv) Detailed process includes the electron acceptor.

(v) These electron acceptors are sequentially arranged in downhill fashion as primary acceptor → ferredoxin → plastoquinone → Cytochrome complex → plastocyanin
While over the cytochrome complex, the electron energises passage of protons to create a proton gradient for synthesis of ATP from ADP and inorganic phosphate.

Q.5. Where does non-cyclic photophosphorylation takes place ? Describe the process. Why is the process referred to as non-cyclic ?

[KVS 2012-13] [KVS 2013-14]

OR

Describe non-cyelic photophosphorylation in plants.

OR

Explain non-cyclic photophosphorylation in plants. Why is this process called so ?

Ans. Non-cyclic photophosphorylation:

(i) It takes place in the grana of chloroplasts.

(ii) The process initiates with excitation of special types of chlorophyll molecules P680 and P700 (The letter Pstands for pigment and the figures for the wavelength of light at which these molecules absorb).

(iii) P_{680} and P_{700}, molecules of chlorophyll form the reaction centres or photocentres.

(iv) The accessory pigments and other chlorophyll molecules harvest the solar energy and pass it on to the reaction centres.

(v) Thus, a photon absorbed anywhere in the molecules harvest the solar energy and pass its on to the P_{680} molecule.

(vi) The cluster of pigment molecules which transfer their energy to P_{680} absorb at or below the wavelength of 680 nm.

(vii) Together with P_{680} they form the photosystem II or PS II. Similarly P_{700} forms photosystem I or PS I along with pigment molecules which absorb at or below 700 nm.

(viii) When P_{680} acquires a sufficient quantum of energy, it emits an electron, This electron with high potential energy moves down an electron transport chain and during this process ATP is formed.

(ix) The electron lost from P_{680} is ultimately compensated by P_{700} which transfers it to ferredoxin (an iron-containing protein). In turn, ferredoxin transfers the electron to NADP to generate NADPH.

(x) As synthesis of ATP occurs in light and the process is not cyclic $i.e.$, the same not coming back to the oxidised photosystem or in other words, it needs a constant su
of water molecules to be oxidised and NADP to be reduced, the process is called non-cyclic photophosphorylation.

Q. 6. Esplain chemiosmotic bypothests briefly.

Ans. The chemiosmotic hypothesis has been put forward to explain thse machanism of ATP synthesis in the chloroplast, ATE synthests is linked to the development of pruton gradient actoss the membranes of the thylakoid.

(i) Since splitting of the water molecule takes place on the inner side of the thylakoid membrane the protons produced by the photolysis of water accuimulates within the lumen of the thylakoids.

(ii) As electrons move through the photosystems, protons are transported across the membrane.

(iii) This occur because the primary acceptor ot electron which is located towards the outer side of the membrane transfers its electrons to an hydrogen carrier. Hence this molecule removes a proton from the stroma while transporting an electron.

(iv) When this molecule passes on its electron to the electron carrier on the inner side of the membrane, the proton is released into the lumen side of the membrane.

(v) The NADP teductase enzyme is located on the stroma side of the membrane. Along with electrons that come from the acceptor of electrons of PSI, protons are also needed to reduce NAD^+ to NADPH + H^+ and so these protons are also removed from the stroma.

(vi) As a result, protons in the stroma decrease in number, while in the lumen it increases, thus creating a proton gradient across the thyłakoid membrane.

(vi) This gradientis important because the breakdown of this gradient leads to release of energy. The gradient is broken down due to the facilitated diffusion of protons across the membrane to the stroma through F_0 part of ATP ase.

(vii) The other portion of ATP synthetase called F_1 undergoes conformational change due to the energy produced by the breakdown of proton gradient which enables the enzyme to synthesize several ATP.

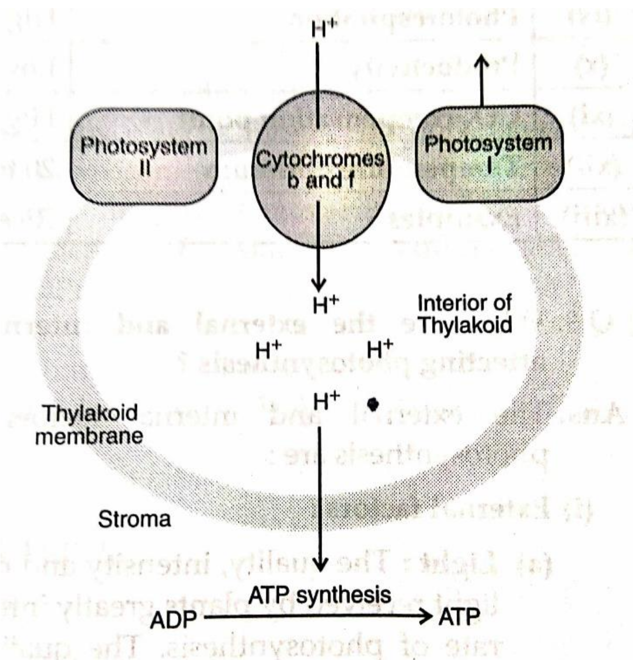


Fig. ATP synthesis through chemiosmotic

Q. 7. What is photorespiration 7 How do some plants like sugafcane minimize the photorespiratory loss? Explain [KVS 2015]

Ans. Photorespiration : It is light dependent process of oxygenation of ribulose biphosphate (RuBP) and release of carbon dioxide by the photosynthetic organs of a plant.
The photorespiratory losses are checked by sugarcane by having physiological adaptations
The process of photosynthests occurs in mesophyll cells and bundle sheath cells.

Mesophyll cells : (i) Initially, CO_2 in taken up by phosphoenol pyruvate (PEP) and changed to oxaloacetate (OAA) in the presence of PEP carboxylase (PEPCO).

(ii) Oxaloacetate is reduced to malate/aspartate, the product formed reach into bundle sheath.

Bundle Sheath : (i) The oxidation of malate (an aspartate) occurs with release of carbon dioxide and formation of pyruvate (3C).

(iii) Due to increased CO_2 concentration, the RuBisco function as carboxylase and not as oxygenase.

(iv) This prevents the photosynthetic losses.

(v) RuBP operates now under Calvin cycle and pyruvates transported back to mesophyil cells changed into phosphoenol pyruvate, to keep the cycle going.

Q. 8. What are the products of light reaction ? Name first stable product of C_3 plants Explain different steps of calvin cycle.

Ans. ATP and NADPH, the product of light reaction are used in synthesis of food. The first CO_2 fixation product in C_3 Plants is 3-phosphoglyceric acid. The CO_2 acceptor is RuBP. Calvin cycle has three stages:

(i) Carboxylation : CO_2 + RuBP → 2 molecule of PGA.

(ii) Reduction : Glucose is formed at the expense of ATP and NADPH It involves 2 ATP for phosphorylation and 2 $NADPH_2$ for reduction per CO_2 molecule fixed.

(iii) Regeneration : RuBP is formed again. 6 turns of Calvin cyde and 18 ATP molecules are required to synthesize one molecule of glucose For diagram: Refer to SAQ-IIL/Q.14.6 CO_2 + 6RuBP + 18 ATP + 12NADPH-$C_6H_{12}O_6$ + 6 RuBP + 18ADP +18Pi + 12NADP.

Q. 9. Difference between C_3 and C_4 pathway.

Ans

S.No.	Characteristics	C_3 Pathway	C_4 Pathway
(i)	Cell type	One (mesophyll)	Two (mesophyll and bundle sheath).
(ii)	Kranz anatomy	Absent in leaves	Present in leaves
(iii)	Chloroplasts type	One type (granal only)	Two types (granal and agranal) Dimorphic
(iv)	CO_2 acceptor	Ribulose 1, 5 bisphosphate (RuBP)	Phosphoenolpyruvate (PEP)

(v)	First CO_2 fixation product	3-PGA (3C compound).	Oxaloacetic acid (4C compound).
(vi)	Carboxylase enzyme	RuBisCO enzyme	PEP carboxylase; RuBisCO
(vii)	CO_2 fixation rate	Low	High
(viii)	O_2 inhibition of photosynthesis	Present	Absent
(ix)	Photorespiration	High	Nil
(x)	Productivity	Low productivity	High productivity
(xi)	CO_2 compensation point	High(25-100μ1 CO_2)	Low(0-10μ1CO_2)
(xii)	Temperature optimum	20 to 25^0 C (Low temperature)	30 to 45°C (High temperature)
(xiii)	Examples	Rice, wheat and potato etc.	Maize, pearl millet, *Amaranthus*, grass etc.

Q. 10. What are the external and internal factors affecting photosynthesis ?

Ans. The external and internal factors affecting photosynthesis are:

(i) External factors:

(a) Light : The quality, intensity and duration of light received by plants greatly influences the rate of photosynthesis. The quality of light influence the photosynthesis as blue and red regions of the visible spectrum are most effective. Green light has minimum effect. When sufficient intensity of light is available, they starts performing photosynthesis. Rate of photosynthesis increase proportionately with an increase in light intensity till plants achieve light saturation point. Beyond this point photosynthesis does show any change. Longer exposure to continuous light favours good photosynthesis.

(b) Carbon dioxide : CO_2 concentration in atmosphere act as a limiting factor. An increase in CO_2 come upto 0.1% shows an increase in photosynthesis. Higher conc. becomes toxic and inhibit the rate of photosynthesis.

(c) Oxygen : High concentration of usygen has an inhibitory effect on photosynthesis in C_3 plants, because RuBP oxygenase becomes more active resulting in photorespiration.

(d) Water: Its photooxidation supplies H^+ for the reduction of NADP. The reduced NADPH_2 is used in the reduction of CO_2 in Calvin cycle. It also donates the electrons to P_{680} in non-cyclic photophosphorylation.

(e) Temperature: Rate of photosynthesis doubles with every 10^0C rise in temperature till the optimum value is achieved. An increase in temperature above 30^0C results in a fall in the rate of photosynthesis.
The optimum temperature for photosynthesis in C_3 plants is 10-25^0C and in C_4 plants it is 30-45^0C.

(ii) Internal factors:

(a) Chlorophyll content: Chlorophyll is essential for cyclic and non-cyclic photophosphorylation and reduction of NADP, the ssimilatory power, used to fix and reduce CO_2 in Calvin cycle.

(b) Leaf anatomy: The important anatomical features that influence photosynthesis include thickness of cuticle, stomatal index, distribution of stomata, degree of opening of stomata, size and distribution of intercellular spaces and number and distribution of vascular strands. Kranz anatomy of C_4 plants increases the efficiency of photosynthesis.

(c) Age of leaf: As leaf develops, the rate of its photosynthesis increases gradually reaching maximum when the leaf becomes fully matured. Rate of photosynthesis decreases with age of leaf.

Q. 11. Name the three cellular organelles that are involved in photorespiration. Mention the various steps of photorespiratory pathway.

OR

Name the cell organelles involved in photorespiration. Explain the mechanism of this process.

[NCT-2007]

Ans. Chloroplast, perosisome and mitochondria are three celilar organelles invalved in photurespiration.

Varinus steps of photorespiratory pathway :

(a) In presence ut high O_2 RuBP cartovylase acts as oxygenase and resuts in formation of 3PGA Phosphoglyceric arid) and 2-phosphoglyoolate 2-phosphoglycolate loses PO_4 igoup to make glycolate.

(b) Siynthesized glycolate in chlomptest enters into peroxisome.

peroxisomes.

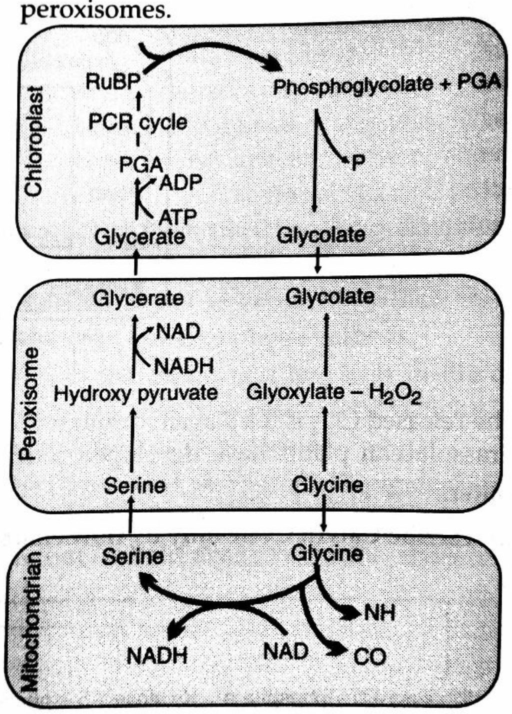


Fig. The photorespiration pathway

(c) The glycolate is oxidised into glyosylate and $H_2 O_2$ by oxidase enzyme.

(d) Clyoxylate is changed into glycine (amino acid) by glutamate glyoxylate transaminase (enzyme).

(e) Two molecules of glycine form serine and one mol. of CO_2 in mitochondria but no ATP and NADPH are formed.

(f) Finally serine passes into mitochondria and is changed into carbohydrate (3 carbon) and Phospłtoglycolate (2 carbon).

(g) Soon glycolate is formed by phosphoglycolate. In peroxisomes, glycolate soon changes into glycine and glycine into serine and CO_2 without production of assimilatory powers (ATP and $NADPH_2$).

Q. 12. How is CAM completed in two phases ? Explain.

Ans. Crassulacean acid metabolism occurs in succulent plants and gets completed in two phases:
Phase 1: (i) Stomata are open at night. CO_2 is absorbed from outside. With the help of PEP carboxylase, it is immediately fixed.

(ii) The acceptor is Phosphoenol pyruvate or PEP.

PEP + HCO_3 (CO_2 + H_2O) $\xrightarrow{\text{PEP Carboxylase}}$ Oxaloacetic acid + H_3PO_4

Oxaloacetic acid + NADPH $\xrightarrow{\text{Dehydregenase}}$ Malic acid + $NADP^+$

(iii) Malic acid is end product of dark fixation of CO_2 It is stored inside cell vacuoles.

Phase II: (i) During day time, stomata are closed. However, light is available for photosynthesis.

(ii) Malic acid moves out of the cell vacuoles.

(iii) It is decarboxylated with the help of malic enzyme.

(iii) Pyruvate is produced and is metabolised.

$$\text{Malic acid (malate)} + \text{NADP}+ \xrightarrow[\text{Enzyme}]{\text{Malic}} \text{Pyruvate} + CO_2 + \text{NADPH}$$

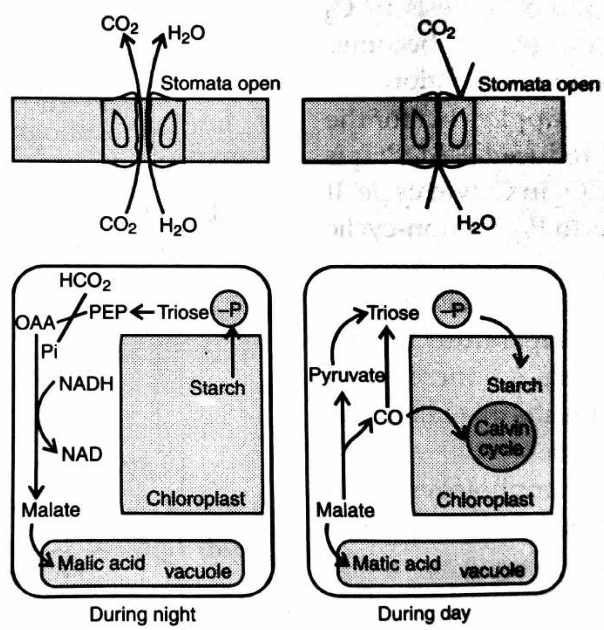


Fig. CAM pathway

(iv) The released CO_2 is fixed again through Calvin cycle with the help of RuBP and Rubisco.

(v) Crassulacean plants have developed a unique mechanism to perform photosynthesis without much lose of water.

Q. 13. Describe calvin cycle by flow chart. **[KVS2013-14]**

Ans.

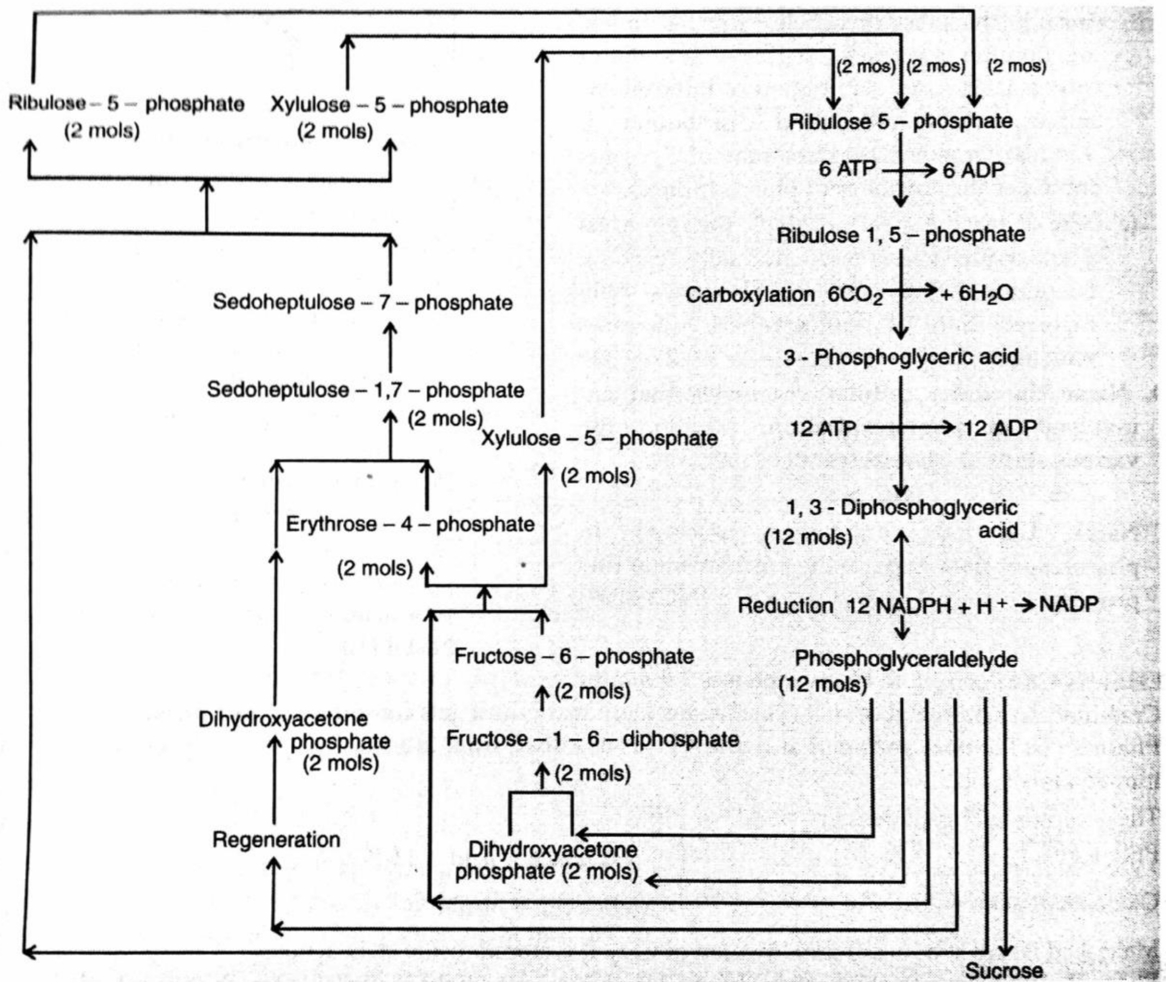


Fig. Flow Chart of Calvin cycle