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PAPER- II

LIFE SCIENCES

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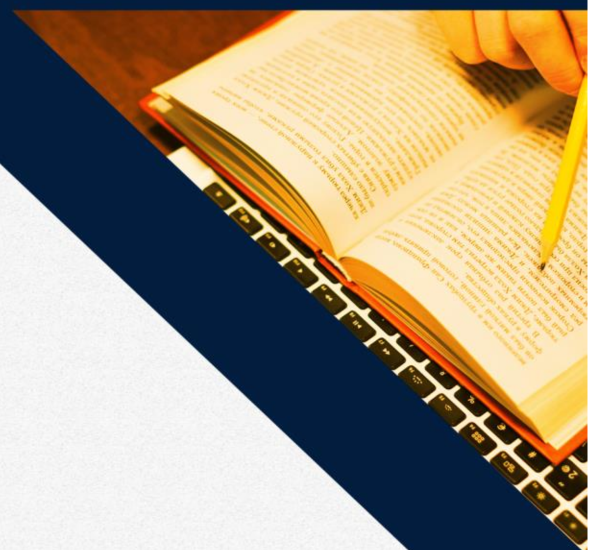

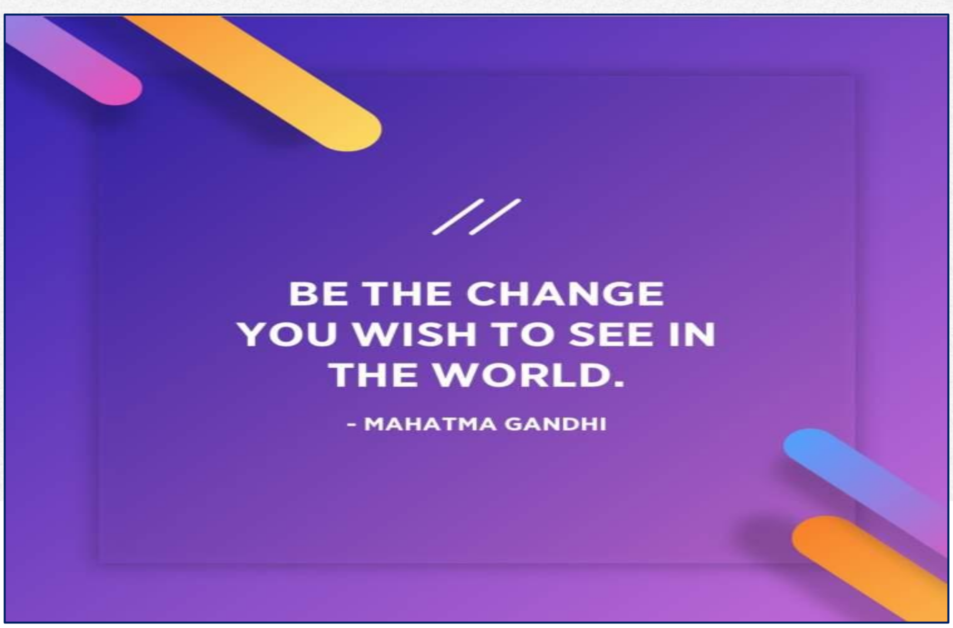

Unit – 6: System Physiology-Plant

SYLLABUS

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1	6.1.1 Light harvesting complex
2	6.1.2 Mechanism of electron transport
3	6.1.3 Photoprotective mechanisms
4	6.1.4 co2 fixation-c3
5	6.1.5 c4 and CAM pathways

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SL. NO	TOPICS
6	6.2.1 Citric acid cycle
7	6.2.2 Plant Mitochondrial ElectronTransport and ATP Synthesis
8	6.2.3 Alternate Oxidase
9	6.2.4 Photorespiratory pathway

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SL. NO	TOPICS
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15	6.5.2 Cryptochromes and Phototropins,
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Section-1: Unit at Glance

Subunit-1 : Photosynthesis

Photosynthesis is the process used by plants, algae and certain bacteria to harness energy from sunlight and turn it into chemical energy .Is the process by which autotrohic organism use light energy to make sugar and oxygen gas from carbon dioxide and water.

The most active photosynthetic tissue in higher plants is the mesophyll of leaf .Mesophyll cells have many chloroplast , which contain the specialized light absorbing green pigment , the chlorophyll. Chloroplast contain different types of pigment ,which help in photosynthesis these are given below –

1. Chlorophyll a , chlorophyll b
2. Carotene , xanthophyll
3. Phycobillins

Site photosynthesis

In plants , photosynthesis takes place in chloroplast which contain the chlorophyll . chloroplasts are surrounded by a double membrane and contain a third inner membrane called the thylakoid membrane , that forms long fold within the organelle.

Chlorophyll molecules appear green to our eyes because they absorb visible light mainly in the region of red and blue parts of the light spectrum , so only some of the light enriched in green wavelengths (i.e about 550nm) is reflected in to our eyes .

A graphical representation of the absorbtion of light by a molecule or substance as a function of the wavelength of light is called the **absorbtion spectrum** of that molecule or substance . The absorbtion spectrum for a particular pigment in a non abosorbing solvent can be determined by a **spectrophotometer**.

Action spectrum, on the other hand, is the effectiveness or efficiency of various wavelength of light in exciting photosynthesis i.e. , The relative effectiveness of light quanta of different energy .

The **red drop effect** sharp decrease in quantum yield at wave length greater than 680 nm in green plants. It is called the “red drop “because it occurs in the red part of spectrum.

The **Emerson effect** is the increase in the rate photosynthesis after chloroplasts are exposed to light of wavelength 670nm(Deep red spectrum) and 700nm (far red spectrum) when simultaneously exposed to light of both wavelength, the rate of photosynthesis is for higher than the sum of the red light and far red light photosynthesis rates.

6.1.1. Light harvesting complex –

Light harvesting Complex (also consisted of chlorophyll and proteins) sarve as extended antenna systems for harvesting additional light energy. In chloroplast there are to LHC . The one associated with PSI is named LHC1 and the one associated with PSII is named LHC 2, accordingly .

Function extended antenna system for harvesting additional light energy and dynamic regulation of energy distribution and electron transport.

A primary eletron acceptor in the reaction center accepts an excited electron from chlorophyll a .photosystems are tightly packed in the thylakoid membrane ,with several hundred antenna chlorophylls and accessory pigments surrounding a photoreaction center .Absorption of a photon by any of the antenna chlorophylls leads to excitation of the reaction center by exciton transfer.

6.1.2. Mechanism of Electron Transport

In this part we will discuss in details the chemical reaction involved in electron transfer during photosynthesis. We will discuss the excitation of chlorophyll by light and the reduction of the first electron acceptor, the flow of electron through photosystem II and I, the oxidation of water as the primary source of electrons, and the reduction of the final electron acceptor (NADP+).

The reaction center chlorophyll of the two photosystem absorb at different wave length

PSI absorb s maximally at 700nm in its reduced state .Accordingly ,this chlorophyll is named P700 .The analogous optical transient of PSII is at 680nm,so its reaction center chlorophyll known as P680. Molecules with unpaired electrons can often be detected by amagnetic resonance technique known as electron spin resonance(ESR).

The PSII reaction center is a multi subunit pigment-protein complex

PSII is contained in a multi-subunit protein supercomplex .In higher plants , themulti sub unit protein super complex has two complete reaction center consists of two membrane proteins known as D1 and D2 as well as other proteins**.**

Water is oxidized to oxygen by PSII

Water is oxidized indicates that four electrons are removed from two water molecules, generating an oxygen molecules and four hydrogen ions.The proton produced by water oxidation are released into the lumen of the thylakoid , not directly into the stromal compartment.They are released into the lumen because of the vectorial nature of the membrane ande the fact that oxygen evolving complex is localized near the interior surface of the thylakoid membrane. These proton are eventualy transafered from lumen to the stroma by translocation through ATP synthase.In this way proton released during water oxidation contribute to electrochemical potential drivingATP formation.

6.1.3 Photoprotective Mechanism

Photoprotection is the biochemical process that helps organisms cope with moleculer damage caused by sunlight .plants and other oxygenic phototroughs have developed a suite of photoprotective mechanisms to prevent photioinhibition.At the moleculer level. The energy in a photon can be damaging, particularly under unfavorable condition. In excess, light energy can lead to the production of toxic species, such as super oxide, singlet oxygen and peroxide, and damage can occur if the kight energy is not dissipated safely . When the rate of photo damage exceeds the rate of repair there is a drop in photosynthetic efficiency, a phenomenon known as photoinhivition .

Carotenoids serve as photo-protective agent

Carotenoids play an essential role in photo protection. When the energy store in chlorophylls in the excited state is rapidly dissipated by excitation transfer or photochemistry, the excited state is said to be quenched.

6.1.4 Co2 Fixation –

Carbon fixation is the process of inorganic carbon to organic compound by living organisms.In carbon reaction required ATP and NADPH which are generated from light energy.In plants three pathway for carbon fixation are c3, c4 and CAM pathway.

6.1.4.1.calvin cycle or c3 cycle

It is cycle reaction occurred in stroma of chloroplast. It is also called dark reaction because this reaction not depedendent on sunlight.In this pathway of reaction consumed ATP and NADPH which are generated from light reaction.The calvin cycle occurred in three stages these are carboxylation, Reduction,Regenereration .

6.1.4.2. c4 Pathway

It is the alternate pathway of C3 cycle to fix CO_2. In this cycle, the first formed stable compound is a 4 carbon compound viz., oxaloacetic acid. Hence it is called C4 cycle. The path way is also called as Hatch and Slack as they worked out the pathway in 1966 and it is also called as C4 dicarboxylic acid pathway. This pathway is commonly seen in many grasses, sugar cane, maize, sorghum and amaranthus.

The C4 plants show a different type of leaf anatomy. The chloroplasts are dimorphic in nature. In the leaves of these plants, the vascular bundles are surrounded by bundle sheath of larger parenchymatous cells. These bundle sheath cells have chloroplasts. These chloroplasts of bundle sheath are larger, lack grana and contain starch grains. The chloroplasts in mesophyll cells are smaller and always contain grana. This peculiar anatomy of leaves of C4 plants is called Kranz anatomy.

6.1.4.2 CAM pathway

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6.1.4.3. PHOTORESPIRATION

The excessive respiration that takes place in green cells in the presence of light is called as photorespiration. Decker (1955) discovered the process and it is also called as C2 cycle as the 2 carbon compound glycolic acid acts as the substrate in photorespiration. In general, respiration takes place under both light and dark conditions. However in some plants, the respiration is more in light than in dark. It is 3-5 times higher than the rate of respiration in dark. Photorespiration is carried out only in the presence of light. But the normal respiration is not light dependent and it is called dark respiration.

SUBUNIT_2

6.2. Respiration is the movement or exchange of gases between the organism and external environment. The plants obtain oxygen from their environment and return carbon dixide and water vapour into it .The biochemical process which occurs within cells and oxidizes food to obtain energy, is known as cellular respiration .Respiration are divided into two group depend upon presence of oxygen aerobic and anaerobic .Aerobic when oxygen is utilized and anaerobic when oxygen is not utilized .

Some coenzyme of oxidation and Reduction process

Coenzyme are non protein compound that is necessary for the functioning of an enzyme.These are NAD,NADP, FMN,FAD,cytochrome co-A etc

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6.2.1GLYCOLYSIS

Glycolysis is the metabolic pathway that converts glucose into pyruvate with simultaneously production of ATP.In this process is also called Emden Meyrhof pathway.In aerobic organisms , glycolysis is the intial phase to the cirtic acid cycle and the electron transport chain , which together harvest most of the energy content in glucose .Glycolysis takes place in the cytosol of all living cells .The enzyme of this pathway are present in the cytosol.

The second stage of glycolysis is the common pathway for all sugars .This is called energy conservation .In this stage there is a single oxidative step for energy conservation. In this stage four molecules of ATP per molecules of glucose degraded

6.2.2The Pentose Phosphate pathway:

The pentose phosphate pathway is a metabolic pathway parallel to glycolysis .It is also known as hexose monophosphate shunt or oxidative phosphate pathway .This metabolic pathway occur in cytoplasm .If generated NADPH and pentose as well as ribolose 5-phosophate, a precursor for the synthesis of nucleotides.

Reaction of this pathway have two phases-

i) Oxidative phase
ii) Non –oxidative phase
iii)

6.2.2.1Roles of oxidative Pentose phosphate pathway in plant Metabolites

Glucose-6-phosphate dehydrogenase is the rate-controlling enzyme of this pathway . It is allosterically stimulate by NADP+ .The ratio of NADPH :NADP+ may be about 100:1 in many cases.An NADPH –utilizing pathway forms NADP+ , Which stimulates Glucose – 6-phodsphate dehydrogenase to produce more NADPH.

6.2.3Citric Acid cycle

The citric acid cycle also known as the TCA cycle .It is also known as Tricarboxylic Acid cycle (TCa cycle) or krebs cycle .TCA cycle is a series of chemical reactions used by all aerobic organisms to release stored energy through the oxidation of acetyl –coA derived from carbohydrates , fats and proteins into adenosine triphosphate and carbon dioxide .Chemical reaction of krebs cycle fall into three main csatagorised.

i) Decarboxylation
ii) Oxidation reduction
iii) Substrate level phosphorylation

.**6.2.4Plant Mitochondrial , the electron transport**

In mitochondria , the electron transfer chain consist of a series of membrane bound redox centers that catalyze the multistep transfer of electrons from NADH and FADH2 forming water and translocating protons from the matrix to the intermembrane space. This maintains a proton motive force composed of a PH gradient and a membrane potentially .

The proton flow back into the matrix along various pathways but particulary through the ATP synthesizing complex embedded in the membrane during ATP synthesis .

6.2.6Alternate oxidase

The alternative oxidase is an enzyme that forms part of the electron transport chain in mitrochondria of different organisms. Most of the all plant have an alternative respritory pathway for reduction of oxygen . This pathway involves the so-called alternative oxidase that , unlike cytochrome –c oxidase , is insensitive to inhibition by Cynide, azide or carbon monoxide. Electron flow through the alternative oxidase is insensitive to classic inhibitors of cytochrome c oxidase . However the alternative oxidase can be specifically inhibited by salicylhydroxnic acid (SHAM) and n-propylgallate .Tissues of higher Plants examined to date demonstrate some amount of cynide –resistant , SHAM-sensitive oxygen uptake that is diagonostic for the alternative oxidase

SUBUNIT-3

6.3. NITROGEN METABOLISM

Plants require higher amounts of nitrogen for the growth and maintenance of life of plants. Nitrogen metabolism include both catabolic and anabolic processes. The anabolic processes are nitrogen fixation, amino acid synthesis and protein synthesis and the catabolic processes are proteiolysis and amino acid destruction, denitrification and nitrification. N2 metabolism Participate in protein synthesis, In the formation of protoplasm, nucleic acids puriens and pyramidines bases, chlorophyll, alkaloids and many co-enzym . Reduction in cell division, cell grow late flowering.

Nitrogen Cycle:-

The nitrogen cycle is the biochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among atmosphere , terrestrial , and marine ecosystem .The conversion of nitrogen can carried out through both biological and physical processes. Important process in the nitrogen in the nitrogen cycle include fixation ,ammonification ,nitrification ,denitrification

6.3.1Nitrate and Ammonium Assimilation

In nitrate (No3) assimilation, the nitrogen in No3 is convested to a higher energy form in nitrate (No2), then to a yet higher energy form in ammonium (NH+4), and finally into the amide nitrogen of glutamine. This process consumes the equivalent 12ATP, per nitrogen (bloom sf.al 1992)

At first nitrate absorbed by the roots and assimilate into organic nitrogen compounds by the plants. Them nitrate reductase enzyme catalized the reaction convert nitrate to nitrite in the cytosol.

Nitrate reductase

Nitrate reductase is the main molybdenum containing protein in vegetative tissues . Nitrate, light, and carbohydrates influence nitrate reductase at the transcription and translation levels.

6.3.1.1Biological nitrogen Fixation:-

Nitrogen fixation is a process by which moleculer nitrogen in the air is converted into ammonia (NH3)or related nitrogenous compounds in soil. when this nitrogen fixation occurs through the agency of some living organism the process is called as biological nitrogen fixation .

6.3.1.2Steps of Nodule Formation:-

Rhizobium multiply and colonise the surrounding of roots (attached to the epidermal root hair cell)The root hair curled up at the tif . Bacteria invade the root hair and enter it.Enzymes from the bacteria degrade the parts of root hair cell wall which Produces a thread Like structure called infection thread. Bacteria invade infection thread and reach upto inner cortex of root. After reaching near the cortex it stimulate the initiation of formation of nodule. The division of cortex cells leads to the formation of mature nodule which makes direct vascular contact with host to nutrient exchange,

6.3.2Biochemistry of Nodulation and nod genes

During development of the root nodules the nodulin genes are differentially expressed. Nod factor also induces several nodules specific plant genes called noduline genes.

Reduction of nitrogen to ammonium occur in bacteroids. Nitrogenase enzyme which catalyzes this reaction is very sensitive to oxygen. In root nodules, the oxygen level is regulated by leghemoglobin.

6.3.2.1.NOD FACTOR:-

Nod factor are lipo chitooligosaccharide, the derivative of chitin. Nod factor of all studied rhizobia are beta 1,4 linked N-acetyl-D- glucosumin. Three of the nod genes (nod A, nodB, nodC) encode enzyme(NodA,NodB,and NodC, respectively) that are required for synthesizing this basic structure(stokkermanset. 1995).

Sub Unit– 4 PLANT HORMONE

6.4 Hormones are numerous chemical substances that influences the growth and development of plant cells and organs .

These substance are signal molecules produced within plants that occur in extremely low concentration . they are organic compounds and are capable of influencing physiological activities leading to promotion , inhibition and modification of growth . plant hormone control all aspects of development , from embryo genesis , the regulation of organ size , pathogen defense , stress tolerance and through to reproductive development .

Example of phytohormone

1. Auxin (IAA)
2. Gibberelin
3. cytokinin
4. Ethyhene
5. Abscisic acid

6.4.1Auxin (IAA) –

Auxins were the first plant horomones to be discovered . Auxin are synthesized in the stem and roots tips and trmsported through Plant axis Auxin promote stem elongation , inhabition growth of lateral buds (maintain apical dominance). Auxin moves to the darker side of the plant ,caausing the cells there to grow longer than corresponding cells on the lighter side of the plant stem tip toword the light , a plant movement knowns as phototropism .

Nature of Auxins :

The principal auxin in plants is indole 3 acetic acid (IAA) . IAA is a derivative of amino acid tryptophan . The compounds which can be converted into auxins are called auxin precursor .

Biosynthesis and transport – two pathway for biosynthesis of IAA , these are –

1. Tryptophan – dependent
2. Tryptophan – independent

6.4.1.1Auxin POLAR TRANSPORT-

Polar transport of auxin is the regulated transport of the plant hormone auxin in plants . it is an active process , the hormone is transported in cell to cell manner and one of the main feature of the transport is its directionality (polarity)

<u>6.4.1.2Function of auxin</u>

Cell growth –

It is generally agreed that auxin serves primarily to regulated cell growth and stem elongation , cell differentiation in xylem and phloem .

Axillary bud growth –

The apical bud is able to exert a dominant influence that suppresses cell division and enlargement in the axillary bud this phenomenon is unknown as apical dominance .

Root elongation and development –

Auxin enhance root elongation . high auxin concentration will promate intiation of secondary root and also adventitious roots on stem .

Parthenocarpy-

The phenomenon of fruit development in the absence of fertilization is known as parhenocorpy .It is a induction of seedless fruits by plant hormones.The three compounds used were auxin indole 3 acetic acid , indole butyric acid and napthalene acetic acid .

Example – pineapple , banana grape , orange , fruit etc.

6.4.1.3Auxin singnaling pathway –

Auxin involved in plant growth and development .It bind to intacellular receptor –TIR1(Transport inhibition Responses). Physiological effect through transcriptional regulation .Inhibition of auxin signaling Aux/IAA proteins .ARF- auxin response factor(Transcriptional activator)

6.4.2Gibberellins –

Gibberellins are plant hormones that regulate various developmental processes , including stem elongation , germination , dormancy , flowering flower development and leaf and fruit senescence. Gibberellins are produced by both fungi and higher plant .

Nature of Gibberllins-

All gibberellins are acidic in nature there are more than 100 gibberellins reported from both fungi and higher plants . They are denoted as GA1 , GA3 and soon . Gibberellic acid is a dihydroxylated gibberellins .

6.4.2.1Bio synthesis –

Precursor – Isoprenoid Unit (IPP)

IPP – lsopentenyl pyrophosphate Biosynthesis include compartment – plastids, ER and cytosol .

GA1 is biologically active gibberellins controlling stem elongation . The precursor of GA1 in higher plants is GA20 . enzyme GA3 oxidase catalyzes the conversion GA20 to GA1 by hydroxylation of c 3 . Lack of enzyme Ga 3 oxidase caves dwarfism in plant .

6.4.2.2.Signaling pathway –

DELLA (nuclear proteins) – repressor –

DELLA proteins such as SLR1 in rice or GA1 and RGA in Arabidopsis are repressors of plant development. DELLAs inhibit seed germination , seed growth , flowering and GA reverse these effects .DELLAs proteins are characterized by the presence of a DELLA motif DELLA contain a DELLA domain and one GRAs domain .

6.4.2.3Function

Seed germination-

Gibberellins induce the production of enzymes like amylases, proteases ,lipases and ribonuclease for mobilizing storage reserves during seed germination and early seedling growth .

Flowering –

Many perennial plants, must achieve a minimum stage of development before they are capable of flowering in the cytosol but when DELLAs bind to PFDs , it restricts them to the nucleus . An important function of PFDs is to assist in the folding of B- tubulin .

Receptor

GA INSENSITIVE DWARF 1 (GID1)- soluble receptor

GA binding to GID1 cause changes in GID1 structure , results in the exposure of a surface which enables the binding of GID1 to DELLA proteins.

Mechamism –

When GA binds to the GID1 receptor , it enhance the interaction between GID1 and DELLA complex . it is thought that DELLA protein undergo change in structure that enable their binding to F-box proteins . F box protein catalyse the .

6.4.3Cytokinins

Cytokinins have a specific effects on cytokinesis that is cell division. Kinetin does not occur naturally in plants. The most wide spread naturally occurring cytokinins in higher plants is zeafin . Cytokinins (ck) are plant growth hormones which are basic in nature. Kinetin does not occur naturally. It is is a synthetic hormone. The first natural cytokinin was obtained from unripe maize grain known as zeatin. It also occur in coconut milk.

6.4.3.1Biosynthesis

The first committed step in cytokinin biosynthesis is the addition of the isopentenylside chain from DMAPP to an adenosine moiety. The plant and bacterial IPT enzymes differ in the adenosine substrate used ,the plant enzymes appears to utilizes AMP. The products of these reaction are convert to zeatin by an unidentified hydroxylase.

6.4.3.2Function

Cell division:

Cytokinins are noted primarily for the ability to induce cell division in plant tissue and cell culturally. Many cells may be induced to undergo division when cultured on artificially media containing cytokines.

Morphogenesis:
Cytokinin also influence morphogenesis in the cultured tissues. High molar concentrations of cytokinin to auxin tend to induce bud development ,while high ratios of auxin to cytokine will encourage root development.

Apical dominance
The application of cytokinin stimulate release of axillary buds from apical dominance thus reversing effect of auxin.

6.4.3.3.Cytokinins signaling pathway
The cytokinin receptor are encoded by a multigene family. Receptor CRE1(cytokinin response 1) contain a conserved extra- cellular cytokinin binding domain called the CHASE domain .Receptor in Arabidopsis for CK signaling –AHKs(AHK2,AHK3 and AHK4),CHASE domain bind to cytokinin in pH dependent manner. Histidine phosphotransfer protein proteins are predicted to mediate the phosphotransfer between sensor kinase and response regulators.

6.4.4.Ethylene
Ethylene is simple gaseous hydrocarbon with the chemical structure $CH_2=CH_2$ .Ethylene is a natural product of metabolism in plants. Ethylene appears to be synthesized in response to stress. Ethylene is a gaseous hormone that forms through the breakdown of methionine which is in all cell. Ethylene is produced at a faster rate in rapidly growing and dividing cells ,especially in darkness.

6.4.4.1Biosynthesis
The amino acid methionine is the Precursor of ehelene . The rate –limiting step in the conversion of AdoMet to ACC, which is catalyzed by the enzyme ACC synthase .The last step in the pathway , conversion of Acc to ehelyne required oxygen and is catalyzed by the enzyme ACC oxidase.

6.4.4.2Function
Vegetative development
Ethylene has been shown to stimulate elongation of stems ,petioles, rrots and floral structure of aquatic and semi aquatic plants.
Fruit Development
A variety of fruits like banana .apples. release ethylene gas during ripening. Ethylene is auto catalytic that is ethylene released by ripening fruits will in turn stimulate maturation and ethylene production by other fruits stored nearby.
Apical dominance
Ethylenes promotes apical dominance and prolong dormancy of lateral buds.
Apo geotropism
It decrease the sensitivity to gravity. It promotes Apo geotropism in roots.
Senescence
It increases the speed of senescence of leaves and flower.

Abscission

Abscission of various part(leaves,flowers ,fruits) is stiumulated by ethylene which induces the formation of hydrolases.

6.4.4.3Ethylene Triple Response

From a genetic standpoint , exposure of dark grown of germinating of Arabidopsis to ethylene cause.

1.Short/reduced hypocotyl (stem elongation).

2.Increase in width of stem (radial swelling of the hypocotyl).

3.Tightening of Apical hook (curl) or horizontal growth of epicotyl with respect of gravity.

Ethylene insensitive mutants

Mutants that fail to response to exogenous ethylene (ethylene resistant) insensitive mutants that do not show a triple in the presence of ethylene.

Example -ETR1,EIN2 , EIN3

Constitutive mutants

Mutants that display the response in the absence of ethylene .

Example -CTR1.

6.4.4.4.SIGNALING PATHWAY

6.4.5Abscisic Acid

Abscisic acid is a simple compound , involved in regulating seed germination
Inducing protein synthesis and modulating water stress.
Abscisic acid Promotes leaf fall and dormancy of buds ,Abscisic acid reverse the
Effect of gibberelines .It is regarded as the stress hormone.ABA is synthesized in vascular tissue of leaves.

6.4.5.1Biosynthesis of ABA

ABA biosynthesis takes place in chloroplasts and other plastids. The pathway with isopentanyl diphosphate (IPP), the biological isoprene unit and leads to synthesis of C40 xanthphyll and violoxanthin.

6.4.5.2.Function-

Abscisic acid promotes leaf fall and dormancy of buds in the seed coat causes dormancy.
ABA decreases the synthesis of RNA and protein in the leaves enhancing the formation of absicission zone which the leaf to detached. Inhibit stomatal opening and promote root growth .

6.4.5.3.ABA signaling in stomatal closure

ABA closes stomata in response to water stress .ABA concentration in leaves can increase up to 50 times under drought conditions .Redistribution or biosynthesis of ABA is very effective in causing stomatal closure and its accumulation in stressed leaves plays an important role in the reduction of water loss by transpiration under water stress condition. Stomatal closing can also be caused by ABA synthesized in the roots and expoted into the shoot.

Sub Unit– 5 SENSORY PHOTOBIOLOGY

6.5Photomorphogenesis

Light is important role in photosynthesis,but also painful for plant growth and development. The light-mediated Change in plant growth and development ,are called photomorphogenesis.

In photomorphogenesis light act as a Signal intiate and regulation . Three major photoreceptor involved in photomorphogenesis, these are -

1. phytoChrome
2. Cryptochrome
3. Phototropin

6.5.1 Phytochrome

It is a photosynthetic Pigment that absorb red and far-red light and Course photomorphogenesis. Phytochrome found in most plant, regulate growth and development Process like induction regulate of flowening, seed germination, stem elongation . It consist of chromophore which is also called phytochromobilins.

6.5.1.1. Classes of phytochrome -

Type-1 phytochrome is light sensitive so in light the transcription of PHY gene inhibited , mRNA degradation and Proteolysis takes place. Type I plastochron mainly tuition tn dark,

Example - PHYA

Tspe-2 phytochrome light stable, so Present in both Light grown and dark grown plants. Type -1 phytochrome mainly function in light.

Example- PHY-B, PHYC, and PHYE

PHY B is most abundant in light grown plant and PHYC -PHYE less abundant.

6.5.1.2 Mode of action of phytochrome

CONSTITUTIVE PHOTOMORPHO GENE- I (COP-1)

Cop-1 is a E3 Ubiquitin ligase, which are involved in targeting Proteins for 26S Proteasome -mediated degradation. It inhibit the photomorphogenesis in dark by degrading the the phytochrome inducing factor (PIFS).

In the dark, cop 1 is present in the nucleus, but in the light it is only found in the cytoplasm.

HY5 – HY5 is a transcription factor tha is a photomorphogenesis in phytochrome pathway. In the light, the level of HY5 protein increase and in the dark it declines.

6.5.2 Cryptochrome –

Cryptochrome is a chromoprotein, .It is a blue Light photo receptor of plant .The word cryptochrome means hidden color.The chromophore for cryptochrome is Flavin and Pterin .Three common Flavins are - riboflavin and its derivatives, FMN and FAD . cryptochrome is a Flavoprotein. Cryptochromes generally found in all plant species.

6.5.2.1 CRYPTOCHROME SPECIAL PROPERTY

Cryptochrome play in important role in the generation and maintaince of Circadiam rhythm. Cryptochrome are structurally similar to photolyases. Photolayses is a blue light activated enzymes

that repairs pyrimidine dimer DNA.

6.5.2.2 Function of Cryptochrome

Crypto chrome importent role in plant that circadian clock, and also stomatal opening . It is also

Stimulate in photomorphogenesis, inhibition of stem elongtion etc.

6.5.3Phototropin

Photropin is a flavoprotein which act as a blue light photo receptor. They are light activating serine (threonine Protein Kinases.This include phototropism, light induced Stomatal opening and chloroplast movement in response to change in light intensity.

Structural Domain of phototropin

1 Phototropin contain two light sensing light –oxygen –voltage (LOV) Domains , LOV1and LOV2.

2 LOV1 and LOV2 bind a chromophore .

3 Blue light irradiation /photoexitation of protein bound FMN cause a conformation change of phototropin that triggers auto phosohorylation and start the sensory transduction cascade(phototropin signaling).

6.5.4Phototropism

phototropin mediate the auxin gradient Change in plot in light. The plant will bend towards the light.The darker side will have high concentration of auxin as compare to light side rapid cell division and elongation at darker side due to high concentration of auxin

Photoperiodism

Photoperiodism is the response of the plants to measure the length of Photoperiods .Garner and Allard were the first to use the term photoperiodism . They observed that Maryland mammoth variety tobacco failed to produce flowers during summer but when grown in green house during winter the plant flowered profusely .

6.5.3.1Plants can be Classified into following types based on 24 hour cycle and darkness

• **Short-day plants**: These plants flower When length is shorter than a certain 'critical Period' under photoperiods longer then a critical point these plants will not flower .

Example- Canabids sativus , Nicotina tabaccum, Glycine max etc.

• **Long day, plants**:

These plants flower when day length is longer then a certain Critical period Under Photoperiod shorter than a critical point these plants will not flower. Example: plantago lanceolata, Beta vulgaris etc..

• **Indeterminate (Day-neutral).**

These plants flowers over a wide range of daylenth from relatively short photoperiods to continuous illumination. Example: Lycospersicum esculentum (tomato)Mirabilis, Capsicum annuum

Sub Unit– 6 Solute Transport and Photoassimilate Translocation

6.6.Solute Translocation

Movement of some inorganic ions and some organic compounds, insoluble formfrom one place to another in higher plants is called as translocation of organic solutes large scale transport between plant and environment or between leaves and roots, is also controlled by membrane transport at the cellular level. For example the transport of sucrose from leaf to root through the phloem, reffered to as tramslocation.

Active absorption of water:

The first step of absorption of water is the imbibition of soil water by the cell surface of root hairs. Plasma membrane being differentially permeable membrane allow solvent against gradient but not salute. The osmotic potential (OP) plays on important role in the absorption of water.The water molecule move from the side of less osmotic potential of water.

Passive absorption of water

It is mode of water absorption in which the force develops in the shoot system where transpiration is going on. Transpiration creates negative pressure in the xylem due to loss of water from the aerial parts. The negative pressure occurs in the xylem sap as water does not split out if a cut is given to a shoot. There are three pathway water movement in root.

6.6.1 Ascent sap

The upward movement of water through stem is called as ascent sap . The sap (i.e water with dissolve minareles) is absorbed mainly by roots and is moved up to all the plant via stem ascent of sap are types of theories to explain ascent of sap.

6.6.1.1.Transpirational pulls cohesion of water theory

Cohesive and adhesive properties of water molecules to form an unbroken continuous water coloum in the xylem .Trans piration pull or ntension exerted on this water upward through the xylem in the plants can achieve fairly high rate .

6.6.2Pressure Flow Model –

This model describe the movement of carbohydrates in phloem . Dissolved carbohydrates flow from a source and are released in sink .Sink include growing root and stem tips as well as developing fruits .

Two steps in translocation require metabolic energy

i)Transport of sucrose and other solutes into the sieve tubes at source , called loading .

ii)Removal of the solutes , called unloading ,where the sieve tubes enter sinks .

SUBUNIT- 7 SECONDARY METABOLITE

6.7 Plants are synthesized different types which may be divide two main groups primary and secondary metabolites are compounds which are not essential for normal growth .Secondary metabolites are required for plant survival and help in response to stress. Secondary metabolites are four major class these are-

1)Terpene

2)Phenolics

3)Alakaloids

4Glycosides

<u>1.Terpenes</u>

Terpenes or terpenoids constitute a large classes of the secondary product . Terpenes technically hydrocarbon while terpenoids, are oxygenated hydrocarbon .Terpene are formed of five carbon isoprenoid, units. The basic structure of terpenes are generally called isoprenoid unit.

6.7.1Biosynthesis pathway-

Biosynthesis of terpenes generally two pathway these are –

1.MVA(Mevalonic acid pathway)
2.MEP(Methyl Erythiosis phosphate pathway)

<u>6.7.2.Phenolics:-</u>

Plant produce a large variety of secondary compouds that contain a phenol group a hydroxyl group a hydroxyl functional group a hydroxyl functional group on an aromatic
ring .Thease substance are classified as phenolics compounds , or phenolics.

Biosynthesis Pathway of phenolics

Phenolics $\longrightarrow$ Shikimic acid pathway and malonic acid pathway

6.7.3Alakaloids

Alkaloids are aromatic nitrogenous compounds.These are organic substance that are produced by plant which act as protective substance against animal insect attacks.

Example-

Narocotic alkaloid used in medicine include morphine and codeine for the relief of pain cocaine as a local anesthetic.

6.7.4.Glycosides

It is a molecule in which carbohydrate (sugar) is bound by a glycosidic bonds to non carbohydrate moiety containing hydroxyl group .

Non Carbohydrate part may be terpenoid , steroids, flavonoids , .

Sub Unit– 8 STRESS PHYSIOLOGY

6.8 Any change in the surrounding environment many disrupt homeostasis. Environment modulation of homeostatic may be defined as biological stress. Plant stress is a adverse effect on the plant which induced upon a sudden transition from some optimal enviromental condition and if disrupts this intial homeostatic state.

Stress in plant can be defined as any external factors that negatively influences plant growth , productivity ,reproductive capacity or survival.

Plant stress divide into two broad catagorised according to different factors these are-

1. Abiotic Stress
2. Biotic stress

1.Abiotic Stress:-

Abiotic stress is negative impact of nonliving factor on the plans in a specific environment.

Example:- light, temperature, water, salt, gravity etc.

2.Biotic Stress:-

Biotic stress is a biological harm (e.g:- insect, pathogen) to which a plant may be exposed during its life time .

Example:- insect, pathogen,etc

6.8.1Temperature Stress effect:-

Heat stress causes divers and often adverse alteration in plant growth, development, physiological processes, and yield. One of the major consequences of H+ stress is the excess formation of reactive oxygen species (Ros) which leads to oxidative stress.

1. .

6.8.2Salt Stress

High salinity affects plants in several ways, water stress, ion toxicity, nutritional disorders, oxidative stress, reduction of cell division, plant growth developments and survival.

All major process such as photosynthesis, protein synthesis and lipid metabolism are affected.

6.8.3Water Stress:-

Plants are required some physical factors, like light, temperature, air, water etc. and some chemical factors like nutrients, organic molecules etc.

Water stress show in plants for two condition of water availability are termed as follows:-

1. **Drought:-**
   It refers to a situation where any area receives annual rainfall less then average rainfall it receives generally .Drought to a situation where transpiration rate exceeds absorbtion rate so plant experience a stress. Water logging (Excess of water) cause blockage of oxygen for plants and their roots. Plant shift from aerobic to nonaerobic condition.

Section – 2: Key Statements

Every candidates appearing for NET/SET examination should follow these key (main) points those can help them a better understanding regarding this unit very quickly.

Basic Key Statements: Chlorophyll(6.1), photosynthetic pigment(6.1), Abosorbtion spectrum(6.1), Action Spectrum(6.1), red drop (6.1), enhancement effect (6.1), photosystem (6..1), light harvesting complex (6.1.1),Glycolysis pathway (6.2.1), some coenzyme of oxidation and reduction process (6.2), Nitrogen cycle (6.3), Biological nitrogen fixation (6.3.1.1), Nitrate reductase (6.3.1), Auxin and nature of auxin (6.4.1), Function of auxin (6.4.1.2), Gibberellin and nature of gibberellin (6.4.2), Function of Gibberellin(6.4.2.3), Function of cytokinin(6.4.3.2), Function of ethelene (6.4.4.2), Function of abscisic acid (6.4.5.2.), Photomorphogenesis(6.5), Photoperiodism(6.5.4), solute translocation (6.6), Ascent sap(6.6.1), secondary metabolite (6.7), Abiotic stress and Biotic stress(6.8), Temperature stress(6.8.1), Salt stress(6.8.2), Water stress(6.8.3),

Standard Key Statements: Z Scheme(6.1.1), Photoprotective mechanism(6.1.3), calvin pathway(6.1.4), c4 pathway (6.1.4), CAM pathway (6.1.4), Photorespiration(6.1.4.3), The pentose phosphate pathway (6.2.2), citric acid cycle(6.2.3), Alternate oxidase(6.2.6),Nitrate and ammonium assimilation (6.3.1), Steps of nodule formation (6.3.1.2), Auxin polar transport(6.4.1), Biosynthesis of Gibberellin(6.4.2.1), Biosynthesis of cytokinin(6.4.3.1),Biosynthesis of ABA(6.4.5.1), phytochrome (6.5.1), cryptochrome (6.5.2), Phototropin(6.5.3), Transpirational pulls cohesion of water theory (6.6.1.1)

Advanced Key Statements:,Mechanism of electron transport (6.1.2)Plant mitrochondrial electron transport chain(6.2.4), Biochemistry of nodulation and nod gene(6.3.2),Nod factor(6.3.2.1), Auxin signaling pathway (6.4.1),Gibberellin signaling pathway(6.4.2.2), cytokinin signaling pathway (6.4.3.3), Ethelene triple response(6.4.4.3), ABA signailing in stomatal Closure (6.4.5.3), Mode of action of phytochrome (6.5.1.2), Pressure Flow model (6.6.2), Biosynthesis pathway of terpens (6.7.1),

[N.B. – Values in parenthesis are the reference number]

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Section – 3: Key Facts and Figures

Sub Unit– 1

PHOTOSYNTHESIS

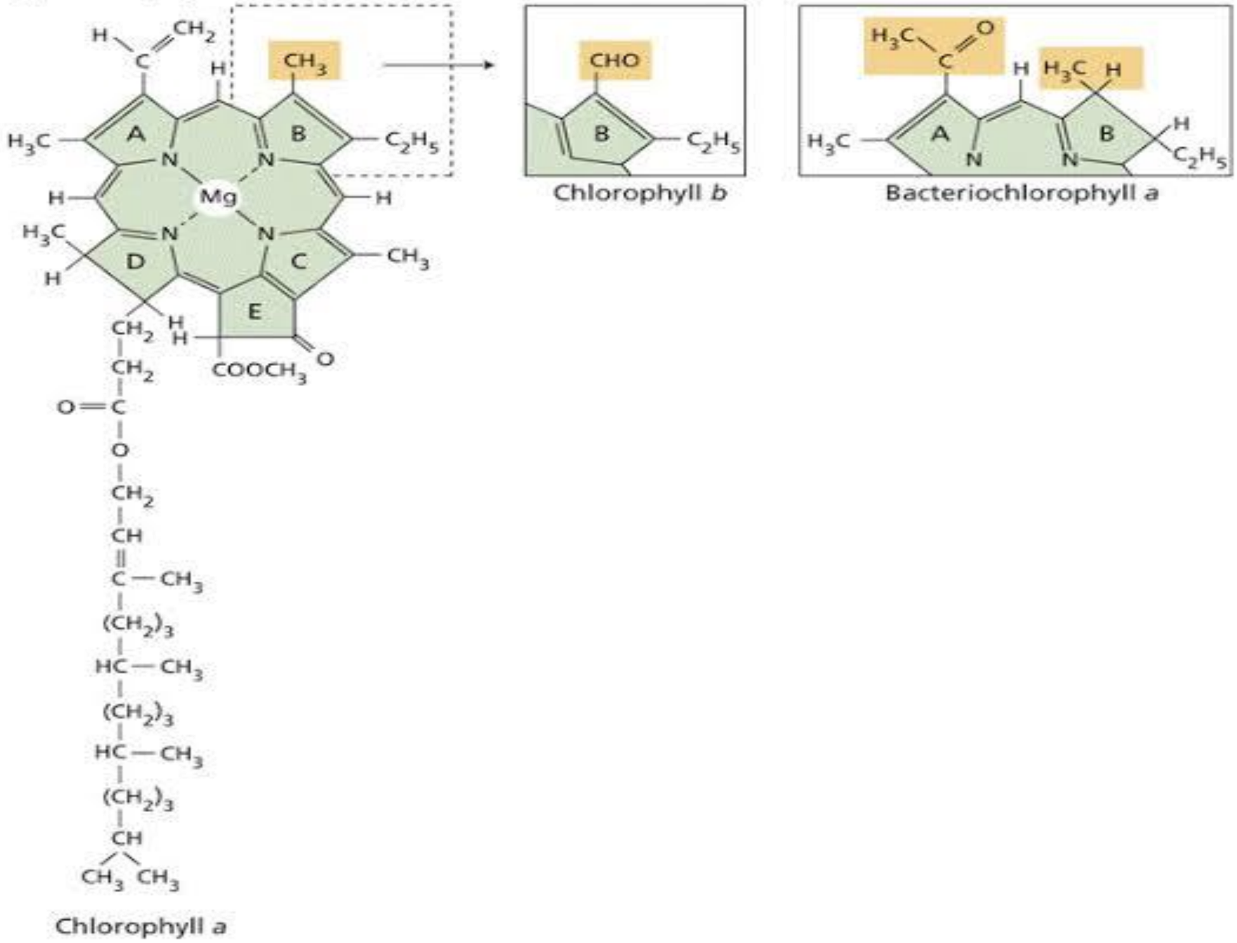
Photosynthesis is the process used by plants, algae and certain bacteria to harness energy from sunlight and turn it into chemical energy .Is the process by which autotrohic organism use light energy to make sugar and oxygen gas from carbon dioxide and water.

$$\underbrace{6CO_2}_{\text{Carbon Dioxide}} + \underbrace{6H_2O}_{\text{Water}} \xrightarrow{\text{Sunlight}} \underbrace{C_6H_{12}O_6}_{\text{Glucose (Energy)}} + \underbrace{6O_2}_{\text{Oxygen}}$$

The most active photosynthetic tissue in higher plants is the mesophyll of leaf .Mesophyll cells have many chloroplast , which contain the specialized light absorbing green pigment , the chlorophyll. Chloroplast contain different types of pigment ,which help in photosynthesis these are given below –

1. Chlorophyll a , chlorophyll b
2. Carotene , xanthophyll
3. Phycobillins

(A) Chlorophylls



PLANT PHYSIOLOGY AND DEVELOPMENT 6e, **Figure 7.6 (Part 1)**

Fig – structure of chlorophyll a, chlorophyll b and baceriochlorophyll

Site photosynthesis

In plants , photosynthesis takes place in chloroplast which contain the chlorophyll . chloroplasts are surrounded by a double membrane and contain a third inner membrane called the thylakoid membrane , that forms long fold within the organelle.

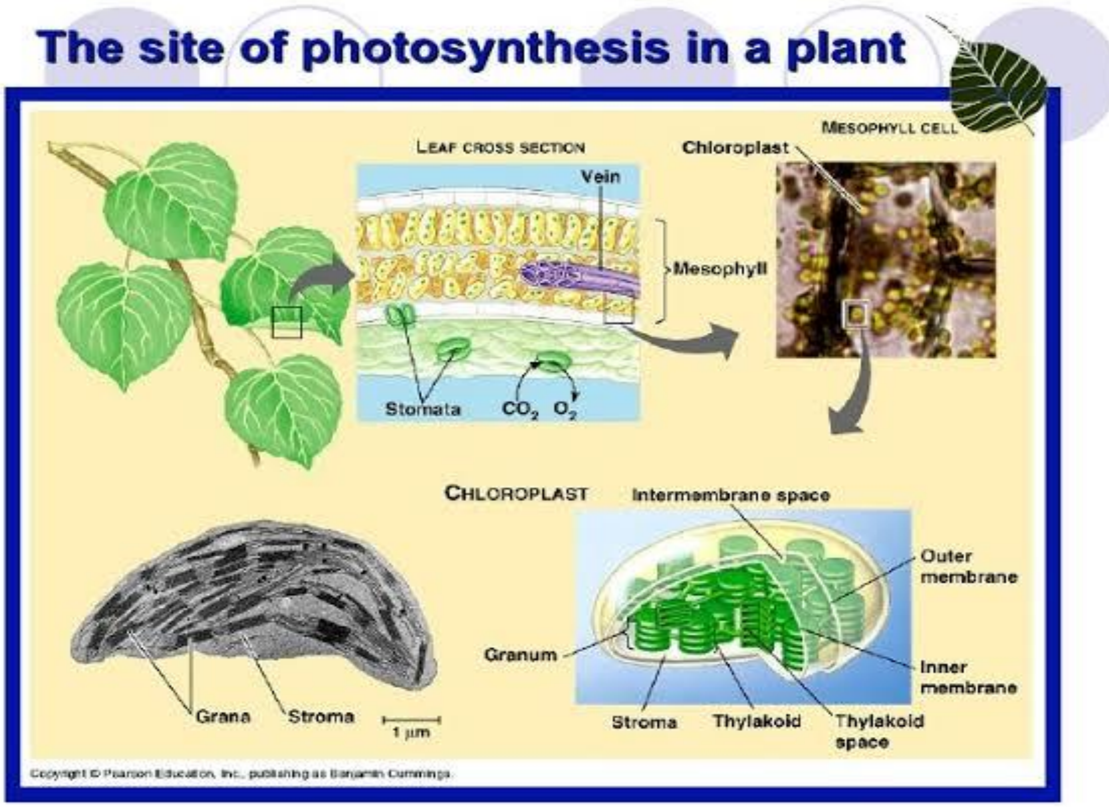


Fig- site of photosynthesis in plant

Chlorophyll molecules appear green to our eyes because they absorb visible light mainly in the region of red and blue parts of the light spectrum , so only some of the light enriched in green wavelengths (i.e about 550nm) is reflected in to our eyes

.

Absorbation spectrum

A graphical representation of the absorbtion of light by a molecule or substance as a function of the wavelength of light is called the **absorbtion spectrum** of that molecule or substance . The absorbtion spectrum for a particular pigment in a non abosorbing solvent can be determined by a **spectrophotometer**.

Action spectrum, on the other hand, is the effectiveness or efficiency of various wavelength of light in exciting photosynthesis i.e. , The relative effectiveness of light quanta of different energy .

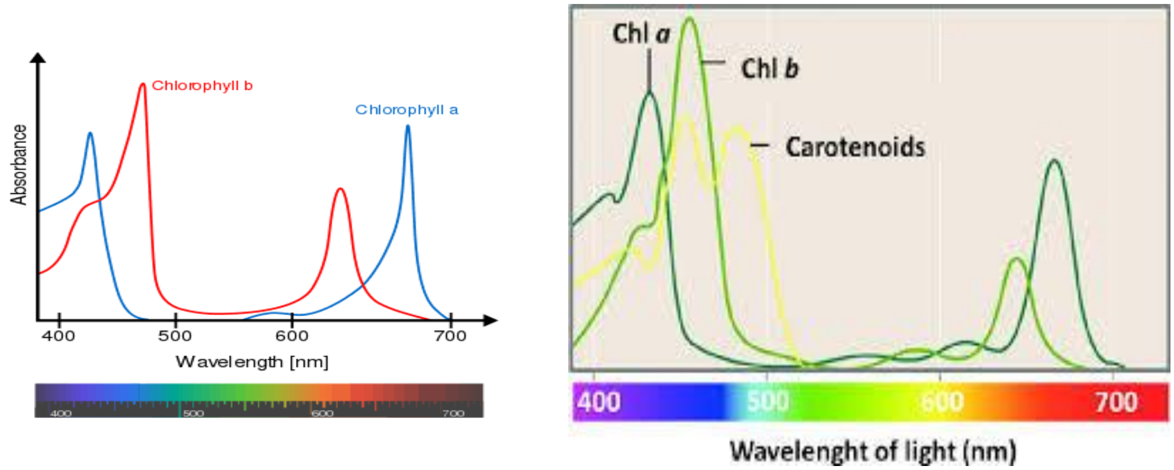


Fig : Abosorbtion spectrum and action spectrum of different chlorophyll pigment

The **red drop effect** sharp decrease in quantum yield at wave length greater than 680 nm in green plants. It is called the "red drop "because it occurs in the red part of spectrum.

The **Emerson effect** is the increase in the rate photosynthesis after chloroplasts are exposed to light of wavelength 670nm(Deep red spectrum) and 700nm (far red spectrum) when simultaneously exposed to light of both wavelength, the rate of photosynthesis is for higher than the sum of the red light and far red light photosynthesis rates.

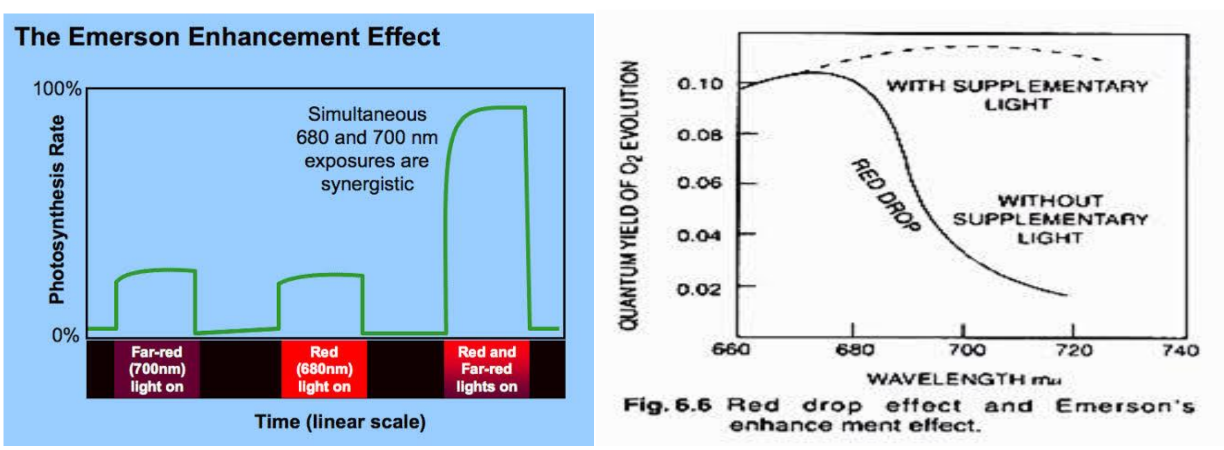


Fig ;- Emerson enhancement effect and red drop effect

Quantum yield:-

In photo synthesis the quantum yield is a measure of photosynthetic efficiency expressed in moles of photons absorb per mole of co2 fixed or o2 evolved.

6.1.1. Light harvesting complex –

Light harvesting Complex (also consisted of chlorophyll and proteins) sarve as extended antenna systems for harvesting additional light energy. In chloroplast there are to LHC . The one associated with PSI is named LHC1 and the one associated with PSII is named LHC 2, accordingly .

Function extended antenna system for harvesting additional light energy and dynamic regulation of energy distribution and electron transport.

A primary eletron acceptor in the reaction center accepts an excited electron from chlorophyll a .photosystems are tightly packed in the thylakoid membrane ,with several hundred antenna chlorophylls and accessory pigments surrounding a photoreaction center .Absorption of a photon by any of the antenna chlorophylls leads to excitation of the reaction center by exciton transfer.

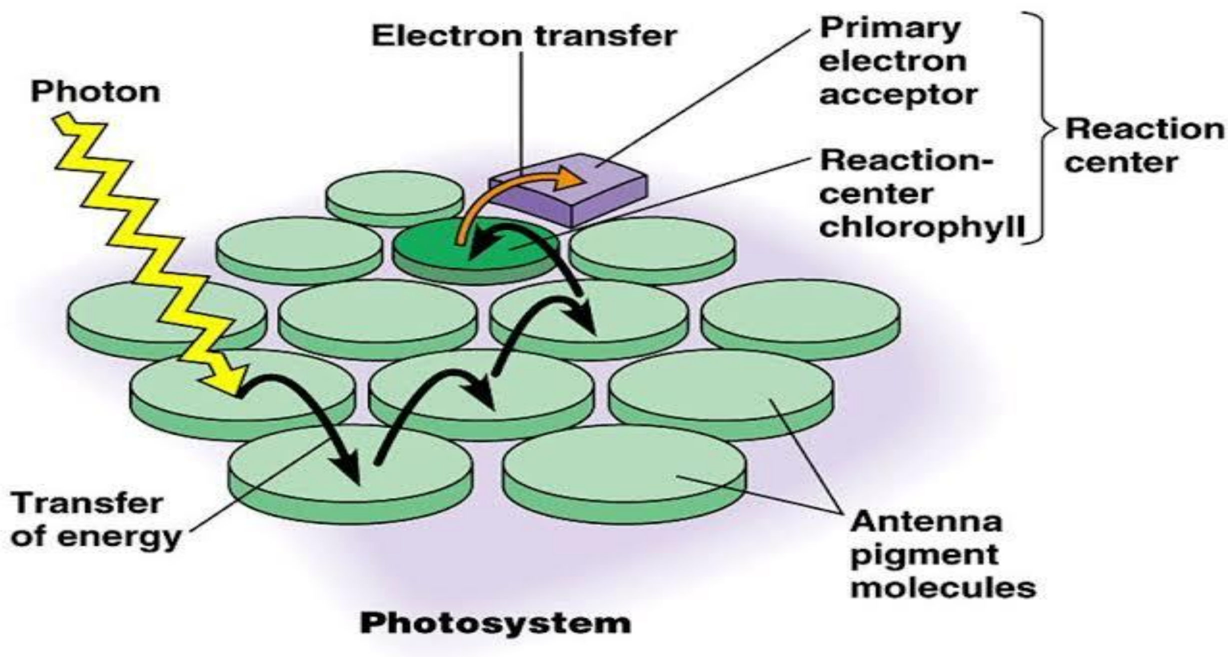


Fig-The reaction center of photosystem

6.1.2. Mechanism of Electron Transport

In this part we will discuss in details the chemical reaction involved in electron transfer during photosynthesis. We will discuss the excitation of chlorophyll by light and the reduction of the first electron acceptor, the flow of electron through photosystem II and I, the oxidation of water as the primary source of electrons, and the reduction of the final electron acceptor (NADP+).

Electrons from chlorophyll travel through the carrier organized in the Z Scheme

Z Scheme , in which all the electron carries known to function in electron flow H_2O to NADP+ are arranged Vertically at the midpoint redox potentials

All most all the chemical process that make up the light reaction of photosynthesis are carried out by four major protein complexes : TSII, The Cytochrome , b6f complex, PAI, and the ATP Synthase. These four integral membrane complexes are vectorially oriented in the thylakoid membrane to function as follows.

- PSII oxidizes water to o2 in the thylakoid lumen and in the process releases protons into the lumen . The reduced product of photo system II is plastohyedroqunine(PQH2).
- Cytochrome b6f oxidizes PQH2 molecules that were reduced by PSIIand delivers electrons toPSI via the soluble copper protein plastocyanin .The oxidation of PQH2 is coupled to proton transfer into the lumen from the stroma ,generating proton motive force.
- PSIreduces NADP+ to NADPH in the stroma by the action of ferredoxin (fd)and flavoprotein ferredoxin –NADP+ reductase (FNR).
- ATP synthase produces ATP as protons diffuse back through it from the lumen into the stroma .

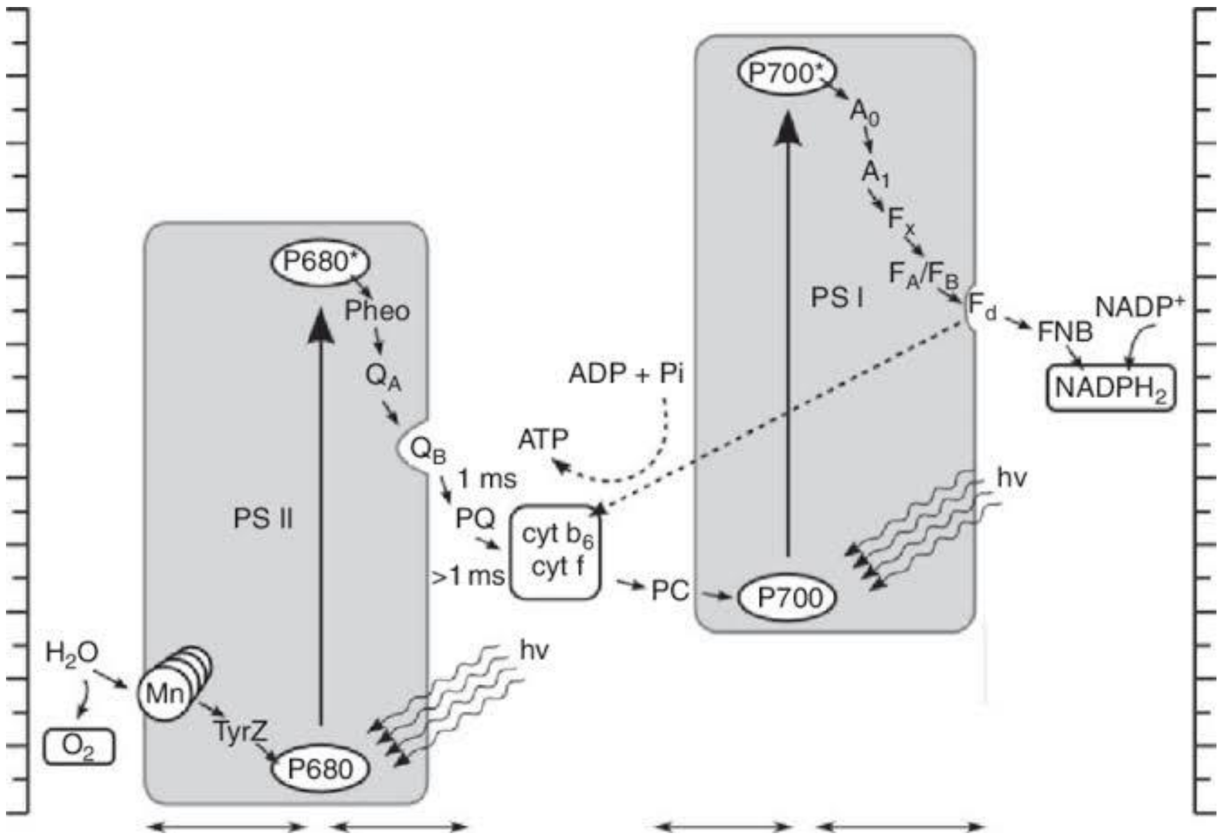


Fig- Z scheme of Photosynthesis

6.1.2.1Proton motive force:-Hydrogen ions will diffuse from an area of lower proton concentration to an area of lower proton concentration to an area of lower proton concentration to an area of lower proton concentration, and an electrochemical concentration gradient of protons across a membrane can be harness to make ATP. This process is also called chemoosmosis.

6.1.2.2.DCMU(3-(3,4-dichlorophenyl)-1,1-dimethyleurea) and paraquat(methyl viologen) :-

DCMU and paraquate are two herbicide that inhabit the photosynthesis.These herbicide block photosynthetic electron flow . DCMU blocks electron flow at the qunone accepters of photosystem II, and paraquat acts by accepting electrons from the early acceptor photosystem I.DCMU also known as diuron .

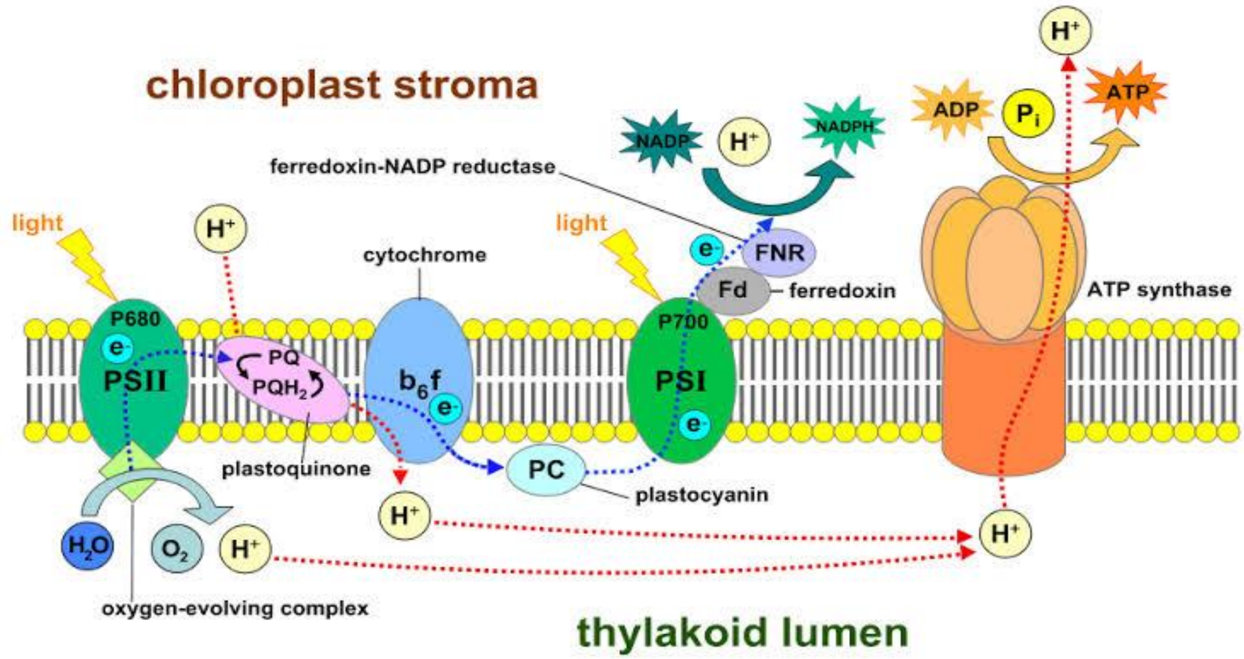


Fig-The transfer electron and protons in the thylakoid membrane

6.1.2.3The reaction center chlorophyll of the two photosystem absorb at different wave length

PSI absorb s maximally at 700nm in its reduced state .Accordingly ,this chlorophyll is named P700 .The analogous optical transient of PSII is at 680nm,so its reaction center chlorophyll known as P680.

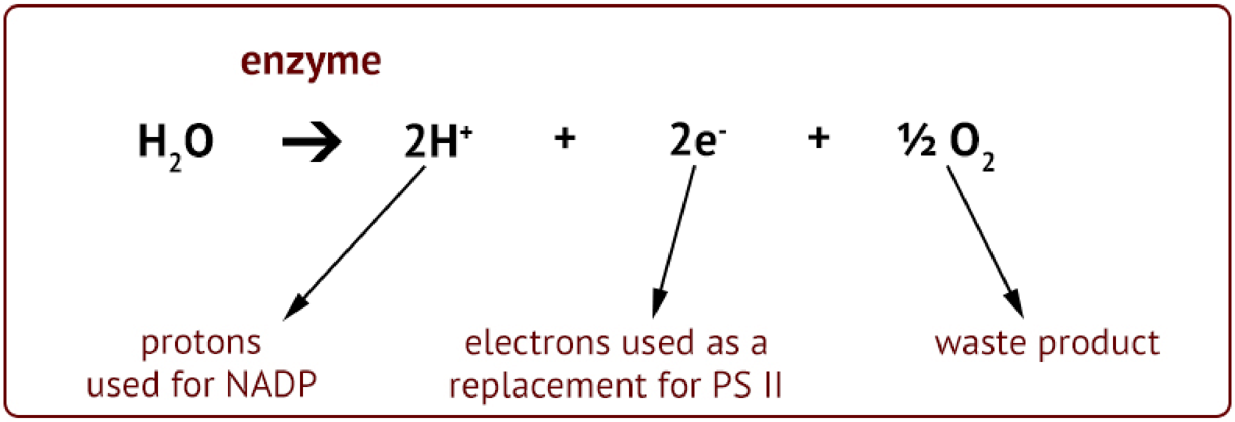
Molecules with unpaired electrons can often be detected by amagnetic resonance technique known as electron spin resonance(ESR).

6.1.2.4The PSII reaction center is a multi subunit pigment-protein complex

PSII is contained in a multi-subunit protein supercomplex .In higher plants , themulti sub unit protein super complex has two complete reaction center consists of two membrane proteins known as D1 and D2 as well as other proteins**.**

6.1.2.5Water is oxidized to oxygen by PSII

Water is oxidized according to the following chemical reaction;



This equation indicates that four electrons are removed from two water molecules, generating an oxygen molecules and four hydrogen ions.The proton produced by water oxidation are released into the lumen of the thylakoid , not directly into the stromal compartment.They are released into the lumen because of the vectorial nature of the membrane ande the fact that oxygen evolving complex is localized near the interior surface of the thylakoid membrane. These proton are eventualy transafered from lumen to the stroma by translocation through ATP synthase.In this way proton released during water oxidation contribute to electrochemical potential drivingATP formation.

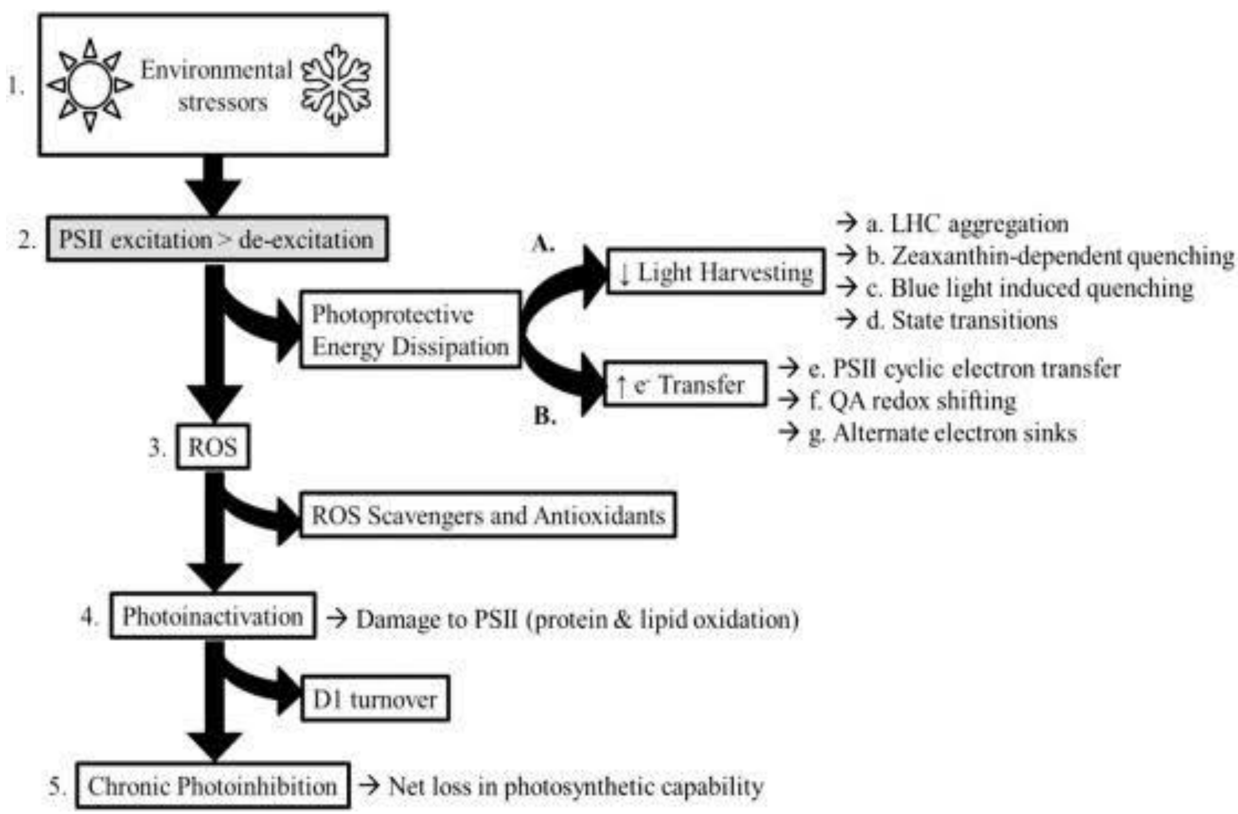
6.1.3 Photoprotective Mechanism

Photoprotection is the biochemical process that helps organisms cope with moleculer damage caused by sunlight .plants and other oxygenic phototroughs have developed a suite of photoprotective mechanisms to prevent photioinhibition.At the moleculer level. The energy in a photon can be damaging, particularly under unfavorable condition. In excess, light energy can lead to the production of toxic species, such as super oxide, singlet oxygen and peroxide, and damage can occur if the kight energy is not dissipated safely .

When the rate of photo damage exceeds the rate of repair there is a drop in photosynthetic efficiency, a phenomenon known as photoinhivition .

The main site of photodamage is the PSII reaction center. PSI is relatively immune from photodamage, and the particular sensitivity of PSII is thought to be due to its unusal chemical properties.

Two different s sequences of chemical reaction leading to photo damage of PSII have been identified, refered to as acceptor side and donor site photoinactivation. Photoinactivation of PSII is thought to be responsible for the high turnover rate of the D1 protein of PSII which, at high light intensities, can be 50 – 80 fold higher than any other thylakoid protein .



Carotenoids serve as photo-protective agent

Carotenoids play an essential role in photo protection. When the energy store in chlorophylls in the excited state is rapidly dissipated by excitation transfer or photochemistry, the excited state is said to be quenched.

If the excited state of chlorophyll is not rapidly quenched by excitation transfer, it can react with molecular oxygen to form and excited state of oxygen known as singlet oxygen. The extremely reactive singlet oxygen goes on to react with and damage many cellular components, especially lipids. The excited satae of carotenoids does not have sufficient energy to form singlet oxygen so, it decays back to its ground state while losing its energy as heat.

Recently carotenoids were to found to play a role in non photochemical quenching which is a second protective and regulatory mechanism.

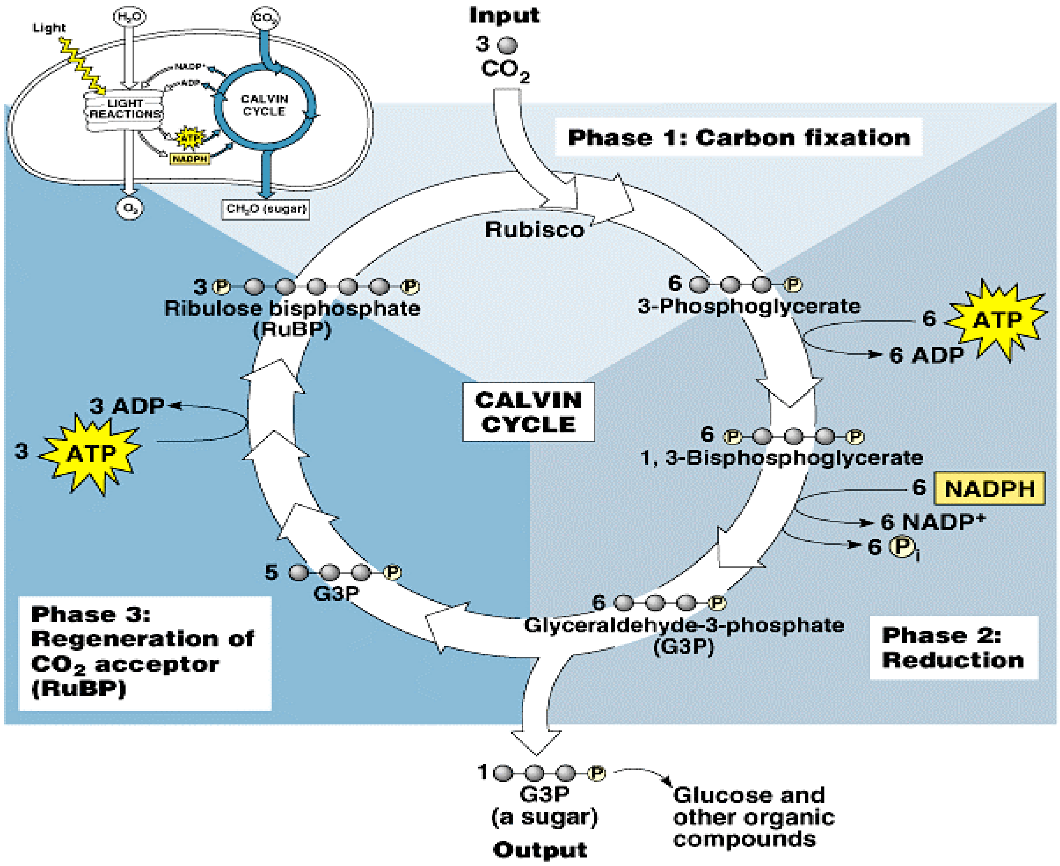
6.1.4 Co2 Fixation –

Carbon fixation is the process of inorganic carbon to organic compound by living organisms.In carbon reaction required ATP and NADPH which are generated from light energy.In plants three pathway for carbon fixation are c3, c4 and CAM pathway.

6.1.4.1Calvin cycle or C3 cycle

It is cyclic reaction of photosynthesis which is occurred in stroma of chloroplast. This reaction, at first carbon fixed with RUBP and atlast converted into sugar molecules. The Calvin cycle was first discovered by Melvin Calvin in chlorella, unicellular green algae. In Calvin cycle the first stable compound is a 3 carbon compound (3 phosphoglyceric acid). The reactions of C3 cycle occur in three stages.

1. Carboxylative phase
2. Reductive phase
3. Regeneration phase



1. Carboxylative phase

In carboxylative phase three molecules of CO_2 are accepted by 3 molecules of 5C compound , RUBP to form three molecules of an unstable intermediate 6C compound. The enzyme, carboxy dismutase catalyzed in this reaction.

3 CO_2 + 3 RUBP $\xrightarrow{\text{Carboxy dismutase}}$ 3 unstable intermediate 6 carbon compound

In the presence enzyme carboxy mutase the three molecules of the unstable 6 carbon compound are converted by the addition of 3 molecules of water into six molecules of 3 phosphoglyceric acid.

3 unstable intermediate 6 C compound + 3 H_2O $\xrightarrow{\text{Carboxy mutase}}$ 3 phosphoglyceric acid

3 phosphoglyceric acid (PGA) is the first stable compound product of C3 pathway .

2. Reductive phase

After the carboxylation reaction, reduction of PGA occurs, wheare ATP and NADPH formed during light reaction are used.Six molecules of 3PGA are phosphorylated by 6 molecules of ATP (produced in the light reaction) to yield 6 molecules of 1-3 diphospho glyceric acid and 6 molecules of ADP. Kinase enzyme catalyzed this reaction.

$$\text{3 Phospho glyceric acid} + \text{ATP} \xrightarrow{\text{Kinase}} \text{1,3 diphospho glyceric acid} + \text{ADP}$$

Six molecules of 1, 3 diphosphoglyceric acid are reduced with the use of 6 molecules of $NADPH_2$ to form 6 molecules of 3 phospho glyceraldehyde. Triose phosphate dehydrogenase enzyme is catalyzed this reaction .

$$\text{1,3 diphospho glyceric acid} + NADPH_2 \xrightarrow{\text{Triose phosphate Dehydrogenase}} \text{3 phospho glyceraldehyde} + NADP + H_3PO_4$$

3. Regenerative phase

After the reductive phase, the ribose diphosphate is regenerated. The regenerative phase is called as *hexose monophophate shunt or pentose phosphate pathway*. It involves the following steps.

1. Some of the molecules of 3 phospho glyceraldehyde into dihydroxy acetone phosphate. Both 3 phospho glyceraldehyde and dihydroxy acetone phosphate then unite in the presence of the enzyme, aldolase to form fructose, 1-6 diphosphate.

$$\text{3 phospho glyceraldehyde} \xrightarrow{\text{Triose phosphate isomerase}} \text{Dihydroxy acetone } PO_4 \text{ (DHAP)}$$

$$\text{3 phospho glyceraldehyde} + \text{DHAP} \xrightarrow{\text{Aldolase}} \text{Fructose 1,6 diphosphate}$$

2. Fructose 6 phosphate is converted into fructose 6 phosphate in the presence of phosphorylase

$$\text{Fructose 1,6 diphosphate} \xrightarrow{\text{Phosphorylase}} \text{Fructose 6 phosphate}$$

3. Some of the molecules of 3 phospho glyceraldehyde instead of forming hexose sugars are diverted to regenerate ribulose 1-5 diphosphate

3 phospho glyceraldehyde Ribulose 1,5 diphosphate

4. 3 phospho glyceraldehyde reacts with fructose 6 phosphate in the presence of enzyme transketolase to form erythrose 4 phosphate (4C sugar) and xylulose 5 phosphate(5C sugar)

3 phospho glyceraldehyde + Fructose 6 phosphate $\xrightarrow{\text{Transketolase}}$ Erythrose 4 phosphate + Xylulose 5 phosphate

5. Erythrose 4 phosphate combines with dihydroxy acetone phosphate in the presence of the enzyme aldolase to form sedoheptulose 1,7 diphosphate(7C sugar)

Erythrose 4 phosphate + DHAP $\xrightarrow{\text{Aldolase}}$ Sedoheptulose 1 ,7 diphosphate

6. Sedoheptulose 1, 7 diphosphate loses one phosphate group in the presence of the enzyme phosphatase to form sedoheptulose 7 phosphate.

Sedoheptulose 1 ,7 diphosphate + ADP $\xrightarrow{\text{Phosphatase}}$ Sedoheptulose 7 phosphate + ATP

7. Sedoheptulose phosphate reacts with 3 phospho glyceraldehyde in the presence of transketolase to form xylulose 5 phosphate and ribose 5 phosphate .

Sedoheptulose 7 phosphate + 3 phospho glyceraldehyde $\xrightarrow{\text{Transketolase}}$ Xylulose 5 phosphate + Ribose 5 phosphate

8. Ribose 5 phosphate is converted into ribulose 1, 5 diphosphate in the presence of enzyme, phosphopentose kinase and ATP. Two molecules of xylulose phosphate are also converted into one molecule of ribulose monophosphate. The ribulose monophosphate is phosphorylated by ATP to form ribulose diphosphate and ADP, thus completing Calvin cycle.

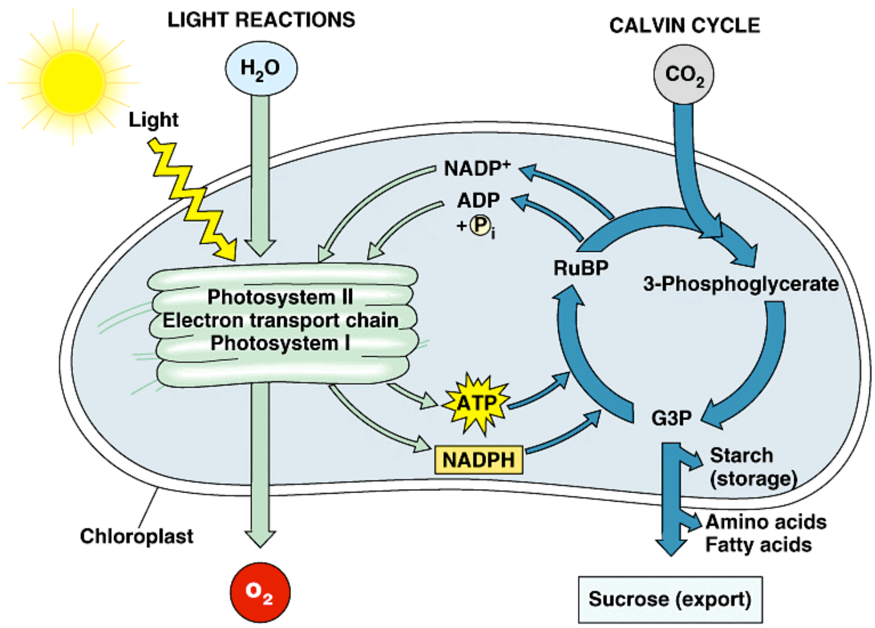
Ribose 5 phosphate + ATP $\xrightarrow{\text{Phophopentokinase}}$ Ribulose 1,5 diphosphate + ADP

2 mols of Xylulose phosphate $\xrightarrow{\text{Phophopentokinase}}$ 1 mol of Ribulose mono phosphate

Ribulose mono phosphate + ATP $\xrightarrow{\text{Phophopentokinase}}$ Ribulose diphosphate + ADP

In the dark reaction, CO_2 is fixed to carbohydrates and the CO_2 acceptor ribulose diphosphate is regenerated. In Calvin cycle, 12 $NADPH_2$ and 18 ATPs are required to fix 6 CO_2 molecules into one hexose sugar molecule (fructose 6 phosphate).

$$6\ CO_2 + 12\ NADPH2 + 18\ ATP \longrightarrow \text{Fructose 6 phosphate} + 12\ NADP+ \ 18\ ADP+ \ 17\ Pi$$



Schematic rpresentation of light reaction and Calvin cycle

C4 cycle or Hatch and Slack pathway

C4 cycle is the alternate pathway of C3 cycle to fix CO_2. In this cycle, the first stable compound formed during carboxylation the oxaloacetic acid. Hence it is called C4 cycle. The path way is also called as Hatch and Slack as they worked out the pathway in 1966 . Certain plants are called c4 plants like maize, sugarcane , pearl millets , sorghum etc. have developed a mechanism to avoid photorespiration.

In C4 plants the chloroplasts are dimorphic in nature. In the leaves of these plants, the vascular bundles are surrounded by bundle sheath of larger parenchymatous cells. In c4 plant the presence of two types of photosynthetic cells, that is mesophyll cells and bundle sheath cells. The chloroplasts in mesophyll cells are smaller and always contain grana. This kind of arrangement is called Kranz anatomy. The bundle sheath cells are granal , whearas chloroplast in the bundle sheath cells are agranal. The C4 cycle involves two carboxylation reactions, one taking place in chloroplasts of mesophyll cells and another in chloroplasts of bundle sheath cells. There are four steps in Hatch and Slack cycle:

1. Carboxylation
2. Breakdown

3. Splitting
4. Phosphorylation

1. Carboxylation

Phosphoenolpyruvate, a 3 carbon compound picks up CO_2 and convert into 4 carbon oxaloacetate in the presence of water. Phosphoenol pyruvate carboxylase is the enzyme that catalyzed this reaction.

$$\text{Phosphoenol Pyruvate (3C)} + CO_2 + H_2O \xrightarrow{\text{PEP carboxylase}} \text{Oxaloacetate (4C)} + H_3PO_4$$

2. Breakdown

After the carboxylation phase Oxaloacetate breaks down into 4 carbon malate and aspartate in the presence of the enzyme, transaminase and malate dehydrogenase.

$$\text{Oxaloacetate (4C)} \xrightarrow[\text{Malate dehydrogenase}]{\text{Transaminase}} \text{Aspartate (4C)} + \text{Malate (4C)}$$

These comp

.

3. Splitting

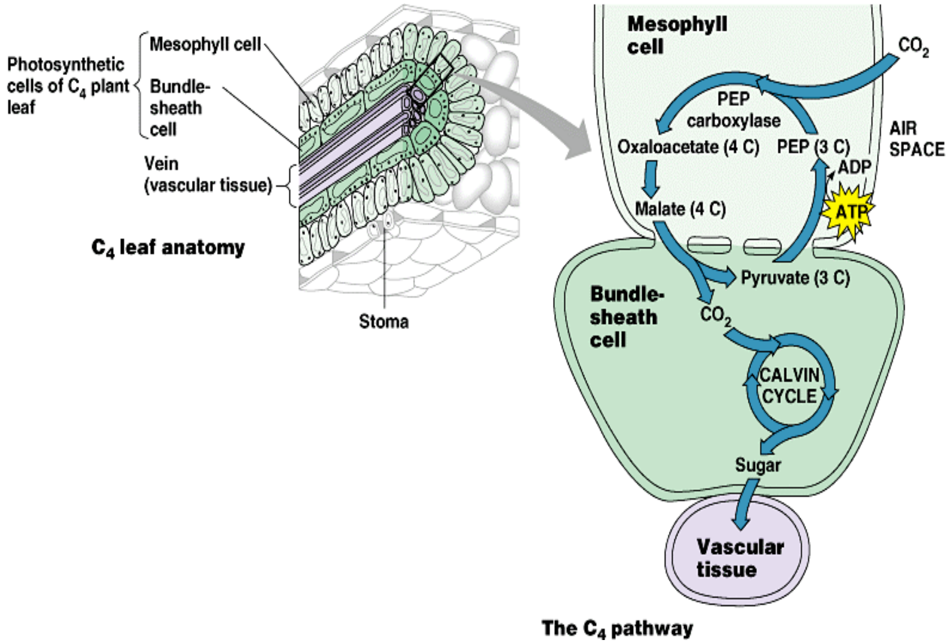
After the breakdown of oxaloacetate in the sheath cells, malate and aspartate split enzymatically to yield free CO_2 and 3 carbon pyruvate.

$$\text{Malate} \xrightarrow{\text{Decarboxylation}} CO_2 + \text{Pyruvate}$$

4. Phosphorylation

After spiliting the pyruvate molecule is transferred to chloroplasts of mesophyll cells where, it is phosphorylated to regenerate phosphoenol pyruvate in the presence of ATP. This reaction is catalysed by pyruvate phosphokinase and the phophoenol pyruvate is regenerated.

$$\text{Pyruvate} + \text{ATP} + \text{Pi} \xrightarrow{\text{Pyruvate phosphokinase}} \text{Phosphoenol pyruvate} + \text{AMP} + \text{Pyrophosphate}$$



Crassulacean Acid Metabolism (CAM) cycle

This cycle refers to mechanism of photosynthesis that occurs in succulent plants that grow in dry conditions. In CAM plants, CO2 is taken up by stomata which remain open in the night . CAM plants are usually succulents and they grow under extremely xeric conditions. In these plants, the leaves are succulent or fleshy. The mesophyll cells have larger number of chloroplasts and the vascular bundles are not surrounded by well defined bundle sheath cells. In these plants, the stomata remain open during night and closed during day time. CAM plants are not as efficient as C4 plants in photosynthesis. But they are better suited to conditions of extreme desiccation.

CAM involves two steps:

1. Acidification
2. Deacidification
3. Acidification

In darkness, the stored carbohydrates are converted into phophoenol pyruvic acid by the process of Glycolysis. The stomata in CAM plants are open in dark and they allow free diffusion of CO_2 from the atmosphere into the leaf. Now, the phosphoenolpyruvic acid carboxylated by the enzyme phosphoenol pyruvic acid carboxylase and is converted in to oxalaoacetic acid.

$$\text{Phosphoenol Pyruvate} + CO_2 + H_2O \xrightarrow{\text{PEP carboxylase}} \text{Oxaloacetic acid} + H_3PO_4$$

The oxaloacetic acid is then reduced to malic acid in the presence of the enzyme malic dehydrogenase. The reaction requires NADPH2 produced in Glycolysis.

$$\text{Oxaloacetic acid} + NADPH_2 + \xrightarrow{\text{Malic dehydrogenase}} \text{Malic acid} + NADP^+$$

The malic acid produced in dark is stored in the vacuole. The malic acid increases the acidity of the tissues.

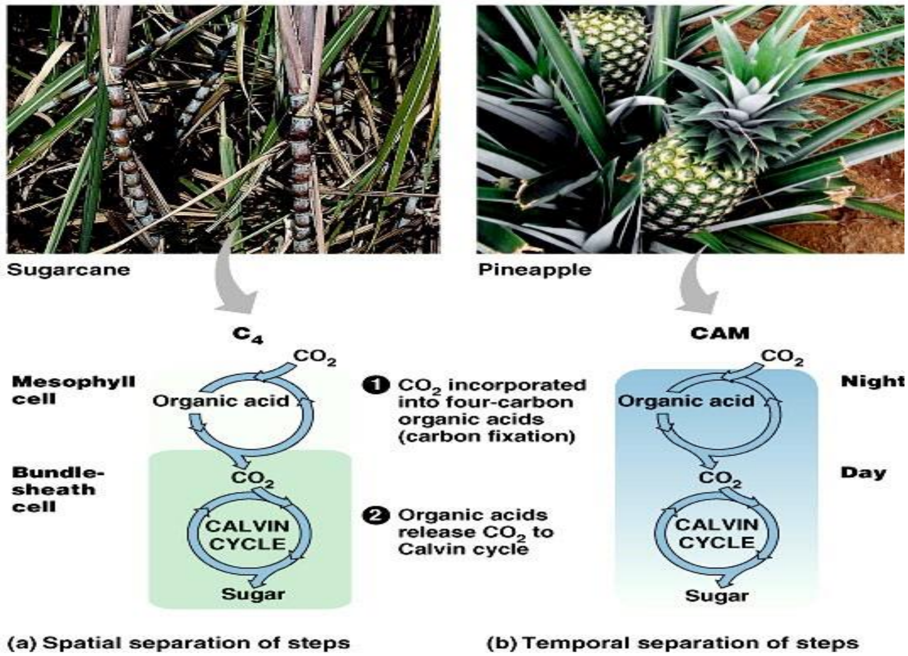
Deacidification

In day time, when the stomata are closed, the malic acid is decarboxylated to produce pyruvic acid and evolve carbon dioxide in the presence of the malic enzyme. When the malic acid is removed, the acidity decreases the cells. This is called deacidification. One molecule of $NADP^+$ is reduced in this reaction.

$$\text{Malic acid} + NADP^+ \xrightarrow{\text{Malic enzyme}} \text{Pyruvic acid} + NADPH_2 + CO_2$$

T

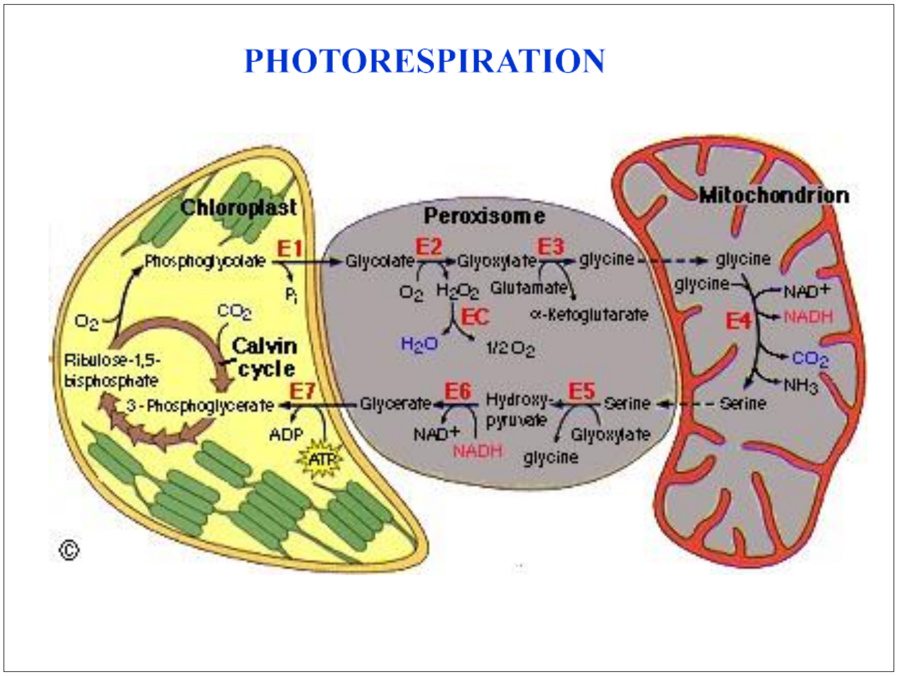
CAM is a most significant pathway in succulent plants. The stomata are closed during day time to avoid transpiration loss of water. As the stomata are closed, CO_2 cannot enter into the leaves from the atmosphere. However, they can carry out photosynthesis during the day time with the help of CO_2 released from organic acids. During night time, organic acids are synthesized in plenty with the help of CO_2 released in respiration and the CO_2 entering from the atmosphere through the open stomata. Thus, the CO_2 in dark acts as survival value to these plants.



PHOTORESPIRATION

Respiration that is initiated in chloroplasts under high light conditions is called as photorespiration. It is also called as C2 cycle as the process discovered by Decar(1955) 2 carbon compound glycolic acid acts as the substrate in photorespiration. In general, respiration takes place under both light and dark conditions. However in some plants, the respiration is more in light than in dark. It is 3-5 times higher than the rate of respiration in dark. Photorespiration is carried out only in the presence of light. But the normal respiration is not light dependent and it is called dark respiration.

Temperature and oxygen concentration play an important role in photorespiration. when the temperature is between 25 and 30 ºC then photorespiration is very high. When increase the concentration of oxygen the rate of photorespiration increases . Three cell organelle are involved in the photorespiration thease are chloroplast, peroxisome and mitochondria. Photorespiration is seen in plants like cotton, pulses, capsicum, peas, tomato, petunia soybean, wheat, oats, paddy, chlorella etc and it is absent in grasses.



Significance of photorespiration

1. Photorespiration helps in classifying the plants

Generally, photorespiration is found in C3 plants and absent in C4 plants.

2. Carbon dioxide is evolved during the process and it prevents the total depletion of CO_2 in the vicinity of chloroplasts

Previous Year Question

June -2014

1. During the operation of C2 oxidative Photosynthetic cycle, which of the following metabolites is transported from chloroplast to peroxisome?

(A) Glycerate

(B) serine

(C) Glycine

(D) Glycolate

2. Following statements are relate Phosphorylation

I. Redox reaction of electron transport chain coupled with ATP synthesis are collectively called oxidative phosphorylation.

II. Three major process-glycolysis,oxidative Pentose phosphate pathway and citric acid cycle are releted to oxidative phosphorylation.

III. Electron transport proteins are bound to outer of the two mitochondrial membranes.

IV. In the electron transport chain electrons are transferred to oxygen from NADH.

Which one of the following combination of the above statement is /are correct?

(a) I and IV (c) II and III

(b) III and IV (d) I and III

Answer & Reference Table

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	D	6.1.4.4
2.	2	A	6.1.3

Dcembar-2014

1. proton motive force during oxidative phosphorylation is generated in mitrochondria by
   (a)exchanging protons for sodium ions
   (b) Pumping protons out into intermembrane space
   (c) Pumping hydroxyl ions into the mitrochondrian
   (d) hydrolysis of ATP
2. In chloroplast, the site of coupled oxidation-reduction reaction is the
   (a) outer membrane
   (b) inner membrane
   (c) thylakoid space
   (d) stromal space
3. Which one of the following is not a characteristic property of carotenoids?
   (a) They posses complex porphyrin ring
   (b) They are integral constituent of thylakoid membrane
   (c) They are also called accessory pigments
   (d) They protect plants from damages caused by light
4. Following are certain statements regarding C3, C4and CAM plants?
   1. The ratio of water loss to co2 uptake is higher in CAM plants than it is in either C3 and C4 plants.
   2.The rate of photosynthesis attains maximum rate at lower intracellular Co2 partial pressure in C4 plants than in C3 plants.

   3.The compensation point in C3 plants are always lower than C4 plants.

   4.plants with c4 metabolism need less rubisco than C3 plants to achieve a given rate of Photosynthersis.

Which one of the following combinations of above statement is/are correct?

(a) 1and 2

(b)1 and 3

(c)3 and 4

(d)2 and 4

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	B	6.1.3
2.	2	C	
3.	3	D	6.1.4

JUNE-2015

1.The quantum yield of oxygen evolution during photosynthesis drastically drops in far-red light. This effect is known as

(a) far-red drop
(b) red drop
(c) blue drop
(d) visible spectrum drop

2.A Z scheme describes eletron transport in o2 –evolving photosynthetic organisms. The direction of electron flow is presented in the following sequences.

1. P680* → pheophytin → QA → QB → PC → cytochrome b6f → P700
2. p700* → phynnoquinone → FeSA → FeSB → FeSX → Fd
3. P680* → pheophytin → QA → QB → cytochrome b6f → PC P700
4. P700* → phylloquinone → FeSX → FeSA → FeSB → Fd

Which one of the fellowing comibinations is correct ?

a) 1 and 2 b) 2 and 3 , c) 3 and 4 d) 4 and 1

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	B	6.1
2.	2	C	6.1.2

DECEMBAR-2015

1.Coupling of the reaction centres of oxidative phosphorylation is achieved by which one of the following ?

a) making a complex of all four reaction centres

b)Location all four complexes in the inner membrane

c)Ubiquinone and cytochrome C

d)Pumping of protons

2.The photosynthetic assimilation of atmospheric Co2 by leaves yield sucrose and starch as end products of two gluconeogenic pathways that are physically separated. Which one of the following combination of cell organales are involved in such physical separation of the process?

a)Sucrose in cytosol an starch in mitochondria

b)Sucrose in chloroplasts and starch in cytosol

c)Sucrose in mitochondria and starch in cytosol

d)Sucrose in cytosol and starch in chloroplasts

3.Following are certain statements regarding co2 assimilation in higherb plants.

1.The action of aldose enzyme during calvin –Berson cycle produces fructose 1,6 –bisphosphate.

2. The conversion of glycine to serine take place in mitochondria during c2 oxidative photosynthetic carbon cycle.

3.During c4 carbon cycle , NAD-malic enzymes releases the co2 from the 4-carbon acid , malate yielding a 3-carbon acid ,pyruvate.

4.Malic acid during crassulacean acid metabolism is stored in mitrochondria during dark and release back to cytosol during day.

Which one of the following combination of above statements is/are correct?

a)1,2 and 3 b) 1,3and 4

c)2,3and4 d)1,2 and 4

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	C	6.1.2
2.	2	D	6.1.2
3.	3	A	6.1.4

JUNE-2016

1.which one of the following is the correct order of electron transport during light reaction in the thylakoid membrane of chloroplast ?

1.P680 → cytochrome b6f → PC → PQ

2.p680 → PC → cytochromeb6f → PQ

3.P680 → PQ → PC → cyochromeb6f

4.p680 → PQ → cytochrome b6f → PC

2.Light reaction of photosynthesis are carried out by four major protein complexs Photosystem –I, PSII ,the cytochromeb6f complex and ATP synthase .The following are certain statements on PS-1

A. PSI reaction centre and PSII reaction centre are uniformly distributed in the granal lamellae and stromal lamellae.
B. The electron donor for the P700 of PSI is plastocyanin and electron acceptor of P700* is a chlorophyll known as A_0.
C. The core antenna and P700 are bound to two key proteins PsaA and PsaB.

D. Cyclic electron flow occurs from the reducing side of PSI via plastohydroquinone and b_6f complex. This supports ATP synthesis but does not reduce $NADP^+$

.

Which one of the following combinations of the above statements is correct?

1. A, B and C
2. A, C and D
3. A, B and D
4. B, C and D

3.Ribulose bisphosphate carboxylase (Rubisco) catalyzes both carboxylation and oxygenation of ribulose-1, 5-bisphosphate. The latter reaction initiates a physiological process known as 'photorespiration'. The following are certain statements on photorespiration**:**

E. The active sites on Rubisco for carboxylation and oxygenation are different.

F. One of the steps in photorespiration is conversion of glycine to serine

.

G. 50% of carbon lost in chloroplast due to oxygenation is recovered through photo- respiration.

H. The pathway of photorespiration involves chloroplast, peroxisome and mitochondria.

Which one of the following combinations of above statements is correct?

1. A and C 2. A and D
3. B and D 4. C and D

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	4	6.1.2
2.	2	4	6.1.2
3.	3	3	6.1.4.3.

DECEMBAR-2016

1.The C_4 carbon cycle is a CO_2 concentrating mechanism evolved to reduce photorespiration. The following are stated as important features of the C_4 pathway**:**

A. The leaves of C_4 plants have Kranz anatomy that distinguishes mesophyll and bundle sheath cells.
B. In the peripheral mesophyll cells, atmospheric CO_2 is fixed by phosphoenol pyruvate carboxy- lase yielding a four-carbon acid.
C. In the inner layer of mesophyll, NAD-malic enzyme decarboxylates four-carbon acid and releases CO_2.
D. CO_2 is again re-fixed though Calvin cycle in the bundle sheath cells.

Which one of the following combinations is correct?

1. B, C and D	2. A, B and C
3. A, B and D	4. A, C and D

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	3	6.1.4.2

JUNE-2017

1.The researcher wanted to study light reaction during photosynthesis by blocking photosynthetic electron flow using the herbicide DCMU and paraquat.The researcher listed following observations

A. Both DCMU and paraquate block the electron flow in photosystem-II
B. Both DCMU and paraquate block he electron flow in photosystem_I
C. .DCMU blocks electron flow in photosystem-I while paraquate block in photosystem-II
D. DCMU blocks electron flow in photosystem-II while paraquat blocks in photosystem-I

Which of the following combination of the above statements is incorrect?

1. A,B and C　　2.A,b and D
3.A,C and D　　4.B,C and D

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	1	6.1.2

Sub Unit– 2

RESPIRATION IN PLANT

6.2. Respiration is the movement or exchange of gases between the organism and external environment. The plants obtain oxygen from their environment and return carbon dixide and water vapour into it

.The biochemical process which occurs within cells and oxidizes food to obtain energy, is known as cellular respiration .Respiration are divided into two group depend upon presence of oxygen aerobic and anaerobic .Aerobic when oxygen is utilized and anaerobic when oxygen is not utilized .

Some coenzyme of oxidation and Reduction process

Coenzyme are non protein compound that is necessary for the functioning of an enzyme .These are NAD,NADP, FMN,FAD,cytochrome co-A etc

.

i)NAD (Nicotinamide Adenine dinucleotide /NADP))

NAD is a cofactor that is central to metabolism. Found in all living cells , NAD is called a dinucleotide because it consist of two nucleotides joined through their phosphate groups . NAD exists in two forms an oxidized and reduced form, NAD+ and NADPH respectively .

ii)FMN (Flavin mononucletide)

FMN is coenzyme of lactic acid dehydrogenase , while FAD is that of aldehyde oxidase , D-amino oxidase and fattyacid co-A dehydrogenase .

iii)Cytochromes

Transfer electrons from flavoproteins or other carrier enzyme to cytochrome oxidase .

iv) Coenzyme-A

It contain thioethanolamine –vitamin B pantothenic acid , pyrophosphate and nucleotide adenylic acid.

6.2.1GLYCOLYSIS

Glycolysis is the metabolic pathway that converts glucose into pyruvate with simultaneously production of ATP.In this process is also called Emden Meyrhof pathway.In aerobic organisms , glycolysis is the intial phase to the cirtic acid cycle and the electron transport chain , which together harvest most of the energy content in glucose .Glycolysis takes place in the cytosol of all living cells .The enzyme of this pathway are present in the cytosol.

Glycolysis consist of two stages. In the first stage glucose is enzymatically phosphorylated by ATP and ultimately cleaved to yield 2 molecules of glyceraldehyde 3-phosphate (GAP).This is energy investment stage . In this first stage of glycolysis is called preparatory stage .

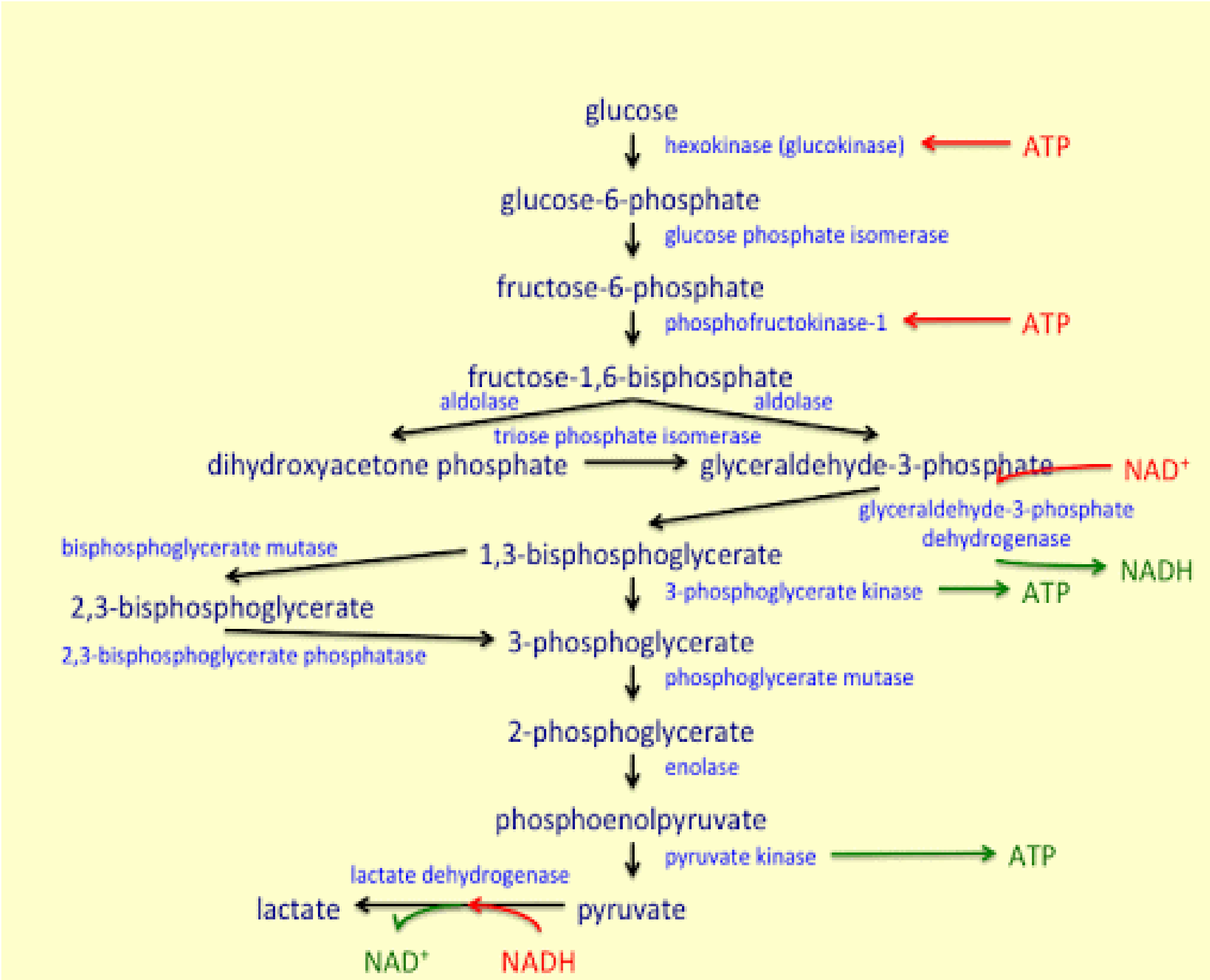


Fig-Glycolysis pathway

The second stage of glycolysis is the common pathway for all sugars .This is called energy conservation .In this stage there is a single oxidative step for energy conservation. In this stage four molecules of ATP per molecules of glucose degraded

<u>6.2.2The Pentose Phosphate pathway</u>:

The pentose phosphate pathway is a metabolic pathway parallel to glycolysis .It is also known as hexose monophosphate shunt or oxidative phosphate pathway .This metabolic pathway occur in cytoplasm .If generated NADPH and pentose as well as ribolose 5-phosophate, a precursor for the synthesis of nucleotides.

Reaction of this pathway have two phases-

iv) Oxidative phase

v) Non –oxidative phase

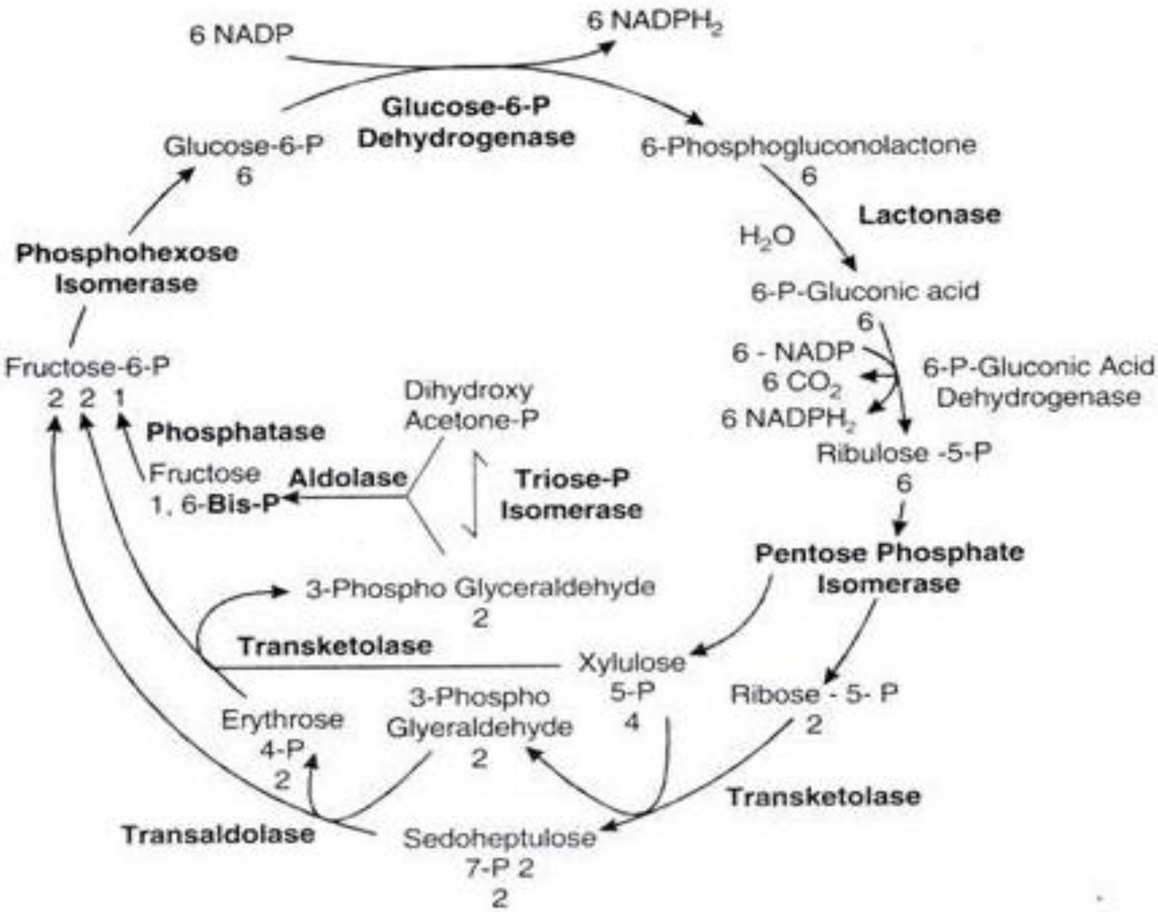


Fig – Pentose phosphate pathway

6.2.2.1Roles of oxidative Pentose phosphate pathway in plant Metabolites

Glucose-6-phosphate dehydrogenase is the rate-controlling enzyme of this pathway . It is allosterically stimulate by NADP+ .The ratio of NADPH :NADP+ may be about 100:1 in many cases.An NADPH – utilizing pathway forms NADP+ , Which stimulates Glucose – 6-phodsphate dehydrogenase to produce more NADPH.

The pathway produces ribose -5 –phosphate , a precursor of the ribose and deoxy ribose needed in the synthesis of RNA and DNA respectively.

In this pathway the four carbon erythrose -4-phosphate , combines with PEP in the intial reaction that produces plant phenolic compounds , aromatic amino acids and phytoalexins.

6.2.3Citric Acid cycle

The citric acid cycle also known as the TCA cycle .It is also known as Tricarboxylic Acid cycle (TCa cycle) or krebs cycle .TCA cycle is a series of chemical reactions used by all aerobic organisms to release stored energy through the oxidation of acetyl –coA derived from carbohydrates , fats and proteins into adenosine triphosphate and carbon dioxide .Chemical reaction of krebs cycle fall into three main csatagorised.

iv) Decarboxylation

v) Oxidation reduction

vi) Substrate level phosphorylation

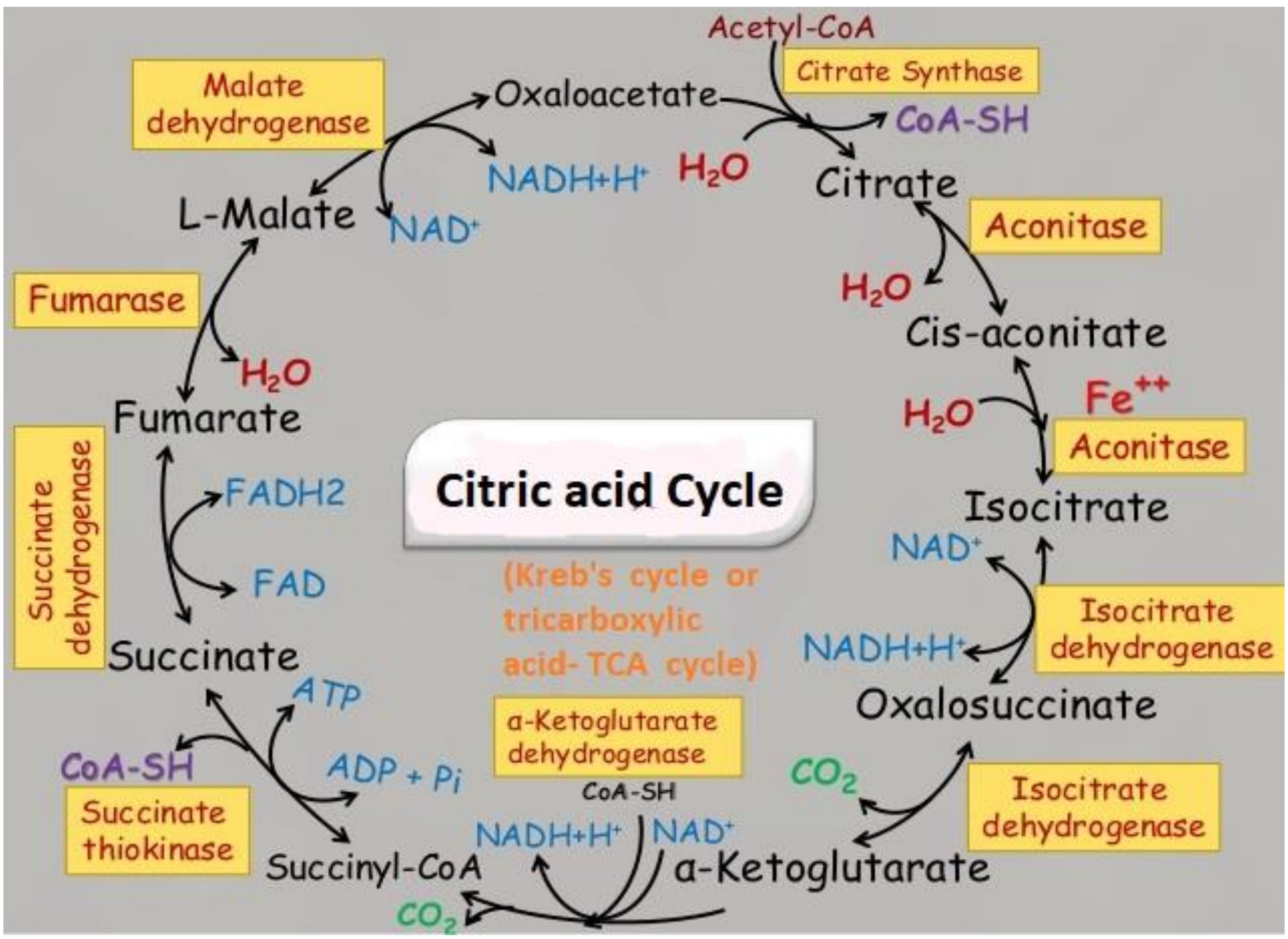


Fig- citric acid cycle

Regulation of citric Acid cycle

Regulation of citric Acid cycle in plant redgulated by enzyme turn over , by metabolic transport from out side the mitrochondrial membrane , by ADP,ATP ratio or by PH.

.

6.2.4Plant Mitochondrial , the electron transport

In mitochondria , the electron transfer chain consist of a series of membrane bound redox centers that catalyze the multistep transfer of electrons from NADH and FADH2 forming water and translocating protons from the matrix to the intermembrane space. This maintains a proton motive force composed of a PH gradient and a membrane potentially .

The proton flow back into the matrix along various pathways but particulary through the ATP synthesizing complex embedded in the membrane during ATP synthesis .

The sequence of events that mediate the flow of electrons from NADH OR FADH2 to o2 via cytochrome oxidase appears to be similar in both animal and plant mitrochondria . Some important differences between animal and plant mitrochondria . some important difference between animal and plant mitochondria have been observed and thease differences in plants are-

1.The respiratory –linked oxidation of external NADH.

2. A cyanide and antimycin A insensitive alternatetive electron pathway .

The main component of the respiratory chain are arranged into multi protein units .

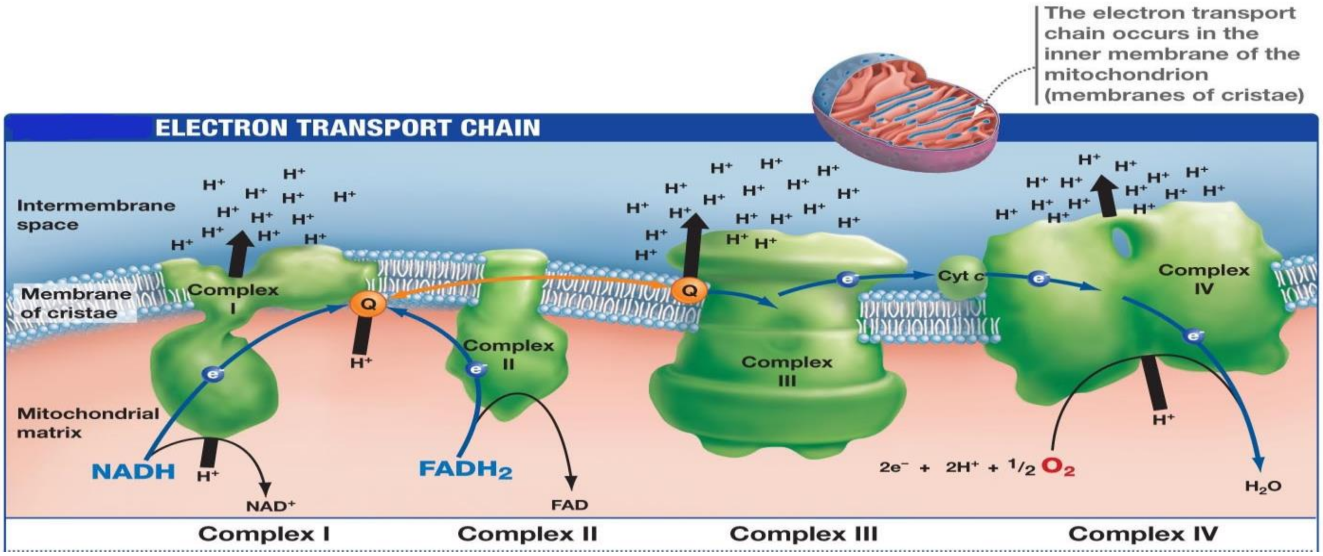


Fig- plant mitrochondrial electron transport chain

Complex –I (NADH:UQ Oxido reductase)

It is the largest of the respiratory enzyme complexes .It accepts electrons from NADH and passes them through a flavin and at least five iron sulfur centers to uboquinone , which transfers its electron to complex III., Complex-I is inhibited specifically by the flavonoid and its analogs , which appear to act at or near the site of ubiqunine reduction .

ComplexII (succinate : UQ Oxidoreductase)

The smallest of the four electron transfer complexs, consist of four proteins .Unlike complex I, complexII, does not translocated protons , so succinate oxidation is linked to the synthesis of less, ATP then is NADH oxidation.

ComplexIII(UQH2: cytochrome c oxidoreductase)

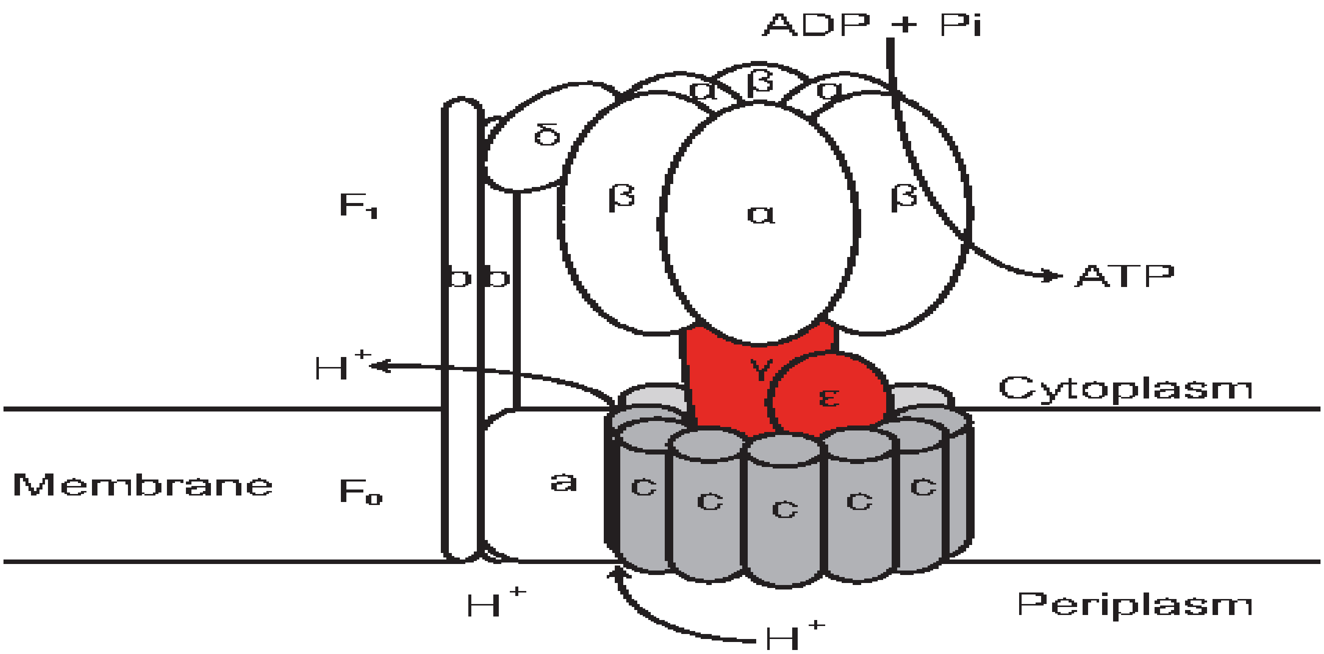
This complex also known as the cytochrome bc, complex, includes a cytochrome b1 a cytochrome C1 a Rieske –type Fe-s protein and five additional polypeptides . ComplexIII has two Quinone –binding sites , one that reduce Ubiqunol(center-P) and one that reduce ubiqunine (center).Thease binding sites and the electron transport cofactors participate in a proton translocation mechanism known as the Q cycle.

ComplexIV(cytochrome c-oxidase)

The final complex of the standard respiratory chain is complexIV, cytochrome –c oxidase. This complex accepts an electron from reduced cytochrome –c on the cytosolic side of the inner membrane4 and eventually donates it to oxygen on the matrix side of the membrane .

6.2.5ATP synthase

The mechanism of mitochondrial ATP synthesis is based on the chemiosmotic hypothesis.According to the chemoosmotic theory , the electrochemical energy inherent in the difference in proton concentration and separation of charge across the inner mitochondrial membrane the proton motive force –drives the synthesis of ATP as protons flow passively back into the matrix through a proton pore associated ATP synthase.



The chemoosmotic theory explains the action mechanism of uncouplers a wide range of chemically unrelated compounds that decrase mitochondrial ATP synthesis but often stimulates the rate of electron transport . all of thease compounds make the inner membrane leaky to protons , which prevents the build up of a sufficiently H+ to drive ATP synthesis.

6.2.6Alternate oxidase

The alternative oxidase is an enzyme that forms part of the electron transport chain in mitrochondria of different organisms. Most of the all plant have an alternative respritory pathway for reduction of oxygen . This pathway involves the so-called alternative oxidase that , unlike cytochrome –c oxidase , is insensitive to inhibition by Cynide, azide or carbon monoxide. Electron flow through the alternative oxidase is insensitive to classic inhibitors of cytochrome c oxidase . However the alternative oxidase can be specifically inhibited by salicylhydroxnic acid (SHAM) and n-propylgallate .Tissues of higher Plants examined to date demonstrate some amount of cynide –resistant , SHAM-sensitive oxygen uptake that is diagonostic for the alternative oxidase

Previous Year Question

JUNE-2015

A.The glycolysis and citric acid cycles are important pathways to generate energy in the cell. Given below are statements regarding the production of ATP.

1.Electrons released during the oxidative steps of glycolysis and cytic acid cycle produce 10 molecules of NADH and 2 molecules of FADH2per molecule of glucose.

2.Electrons released during the oxidative steps of glycolysis and citric acid cycle produced 20 molecules of NADH and 4 molecules of FADH2 per molecule glucose .

3.The coenzyme produced are oxidized by electron transfer chain .

4. The conversion of ADP and pi to ATP takes place in the intermembrane space of mitochondria .

Which one of the following combination of above statement is /are correct?

a)1and 2

b)2 and3

c)3and 4

d)1 and 3

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	d	6.2.4

Sub Unit– 3

NITROGEN METABOLISM

6.3. Plants require higher amounts of nitrogen for the growth and maintenance of life of plants. Nitrogen metabolism include both catabolic and anabolic processes. The anabolic processes are nitrogen fixation, amino acid synthesis and protein synthesis and the catabolic processes are proteiolysis and amino acid destruction, denitrification and nitrification. N2 metabolism Participate in protein synthesis, In the formation of protoplasm, nucleic acids puriens and pyramidines bases, chlorophyll, alkaloids and many co-enzym . Reduction in cell division, cell grow late flowering.

Nitrogen Cycle:-

The nitrogen cycle is the biochemical cycle by which nitrogen is converted into multiple chemical forms as it circulates among atmosphere , terrestrial , and marine ecosystem .The conversion of nitrogen can carried out through both biological and physical processes. Important process in the nitrogen in the nitrogen cycle include fixation ,ammonification ,nitrification ,denitrification .

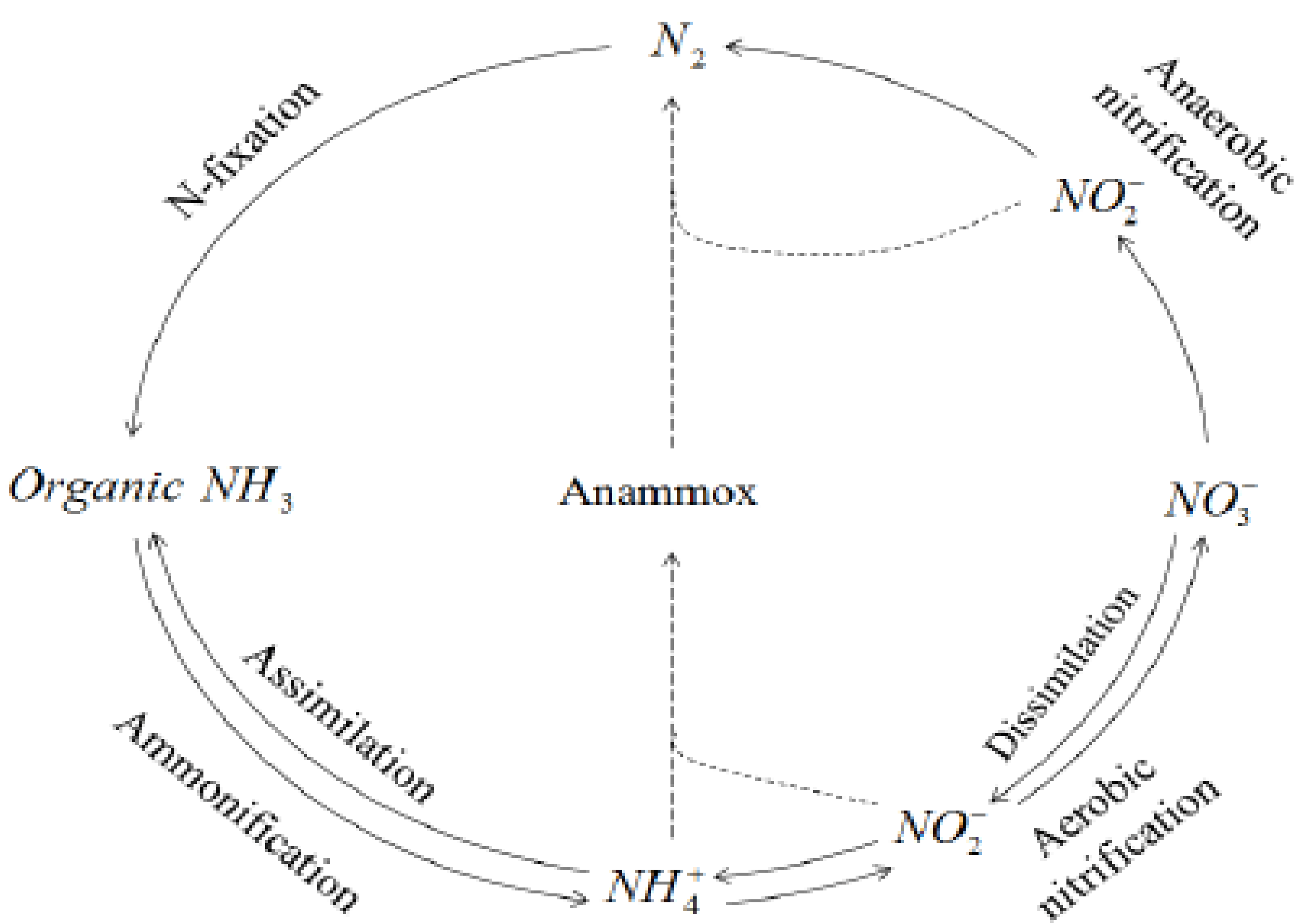


Fig-Nitrogen cycle

6.3.1Nitrate and Ammonium Assimilation

In nitrate (No3) assimilation, the nitrogen in No3 is convested to a higher energy form in nitrate (No2), then to a yet higher energy form in ammonium (NH+4), and finally into the amide nitrogen of glutamine. This process consumes the equivalent 12ATP, per nitrogen (bloom sf.al 1992)

At first nitrate absorbed by the roots and assimilate into organic nitrogen compounds by the plants. Them nitrate reductase enzyme catalized the reaction convert nitrate to nitrite in the cytosol.

Nitrate reductase

Nitrate reductase is the main molybdenum containing protein in vegetative tissues . Nitrate, light, and carbohydrates influence nitrate reductase at the transcription and translation levels. Nitrate reductase reduce nitrate to ammonium to the following reaction.

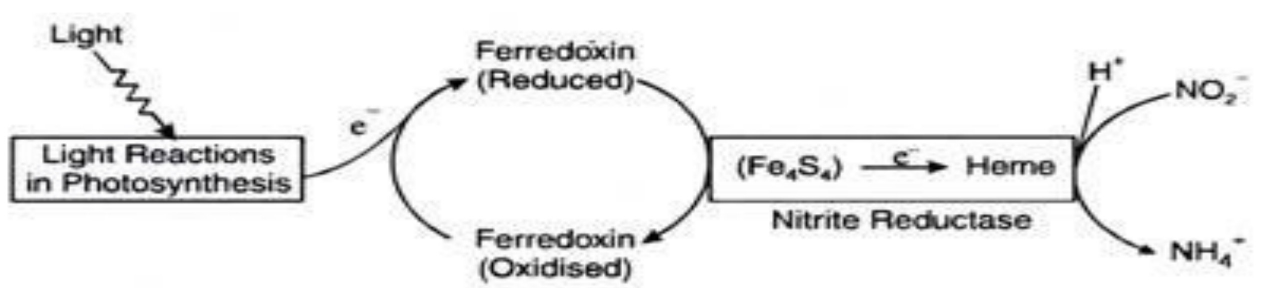


Fig. 9.3. Recent view of reductionof NO_2^- to NH_4^+ in chloroplasts in leaves.

6.3.1.1Biological nitrogen Fixation:-

Nitrogen fixation is a process by which moleculer nitrogen in the air is converted into ammonia (NH_3)or related nitrogenous compounds in soil. when this nitrogen fixation occurs through the agency of some living organism the process is called as biological nitrogen fixation .

- Conversion of nitrogen into ammonia.
- Ammonia is a first stable product of biological nitrogen fixation

The Legume:-

Plants that contribute to nitrogen fixation include those of the legume such as clover, soybeans, alfalfa, lupines, peanuts, etc. They contain symbiotic bacteria called rhizobia with nodules in their root system, producing nitrogen compound that help the plant to grow and compete with other plants. When the plant dies, the fixed nitrogen is released, making it available to other plants, this helps to fertilize the soil.

Nodule Formation:-

Nodule root nodules one organs induced on most species of legume plants by symbiotic,N_2 fixing bacteria the genera Azorhizobium , Brady rhizobium, Rhizobia, Collectively called rhizobia.

Nodule formation involved several phytohormone to Two processes infection and nodule organogenesis.

6.3.1.2Steps of Nodule Formation:-

Rhizobium multiply and colonise the surrounding of roots (attached to the epidermal root hair cell)The root hair curled up at the tif . Bacteria invade the root hair and enter it.Enzymes from the bacteria degrade the parts of root hair cell wall which Produces a thread Like structure called infection thread. Bacteria invade infection thread and reach upto inner cortex of root. After reaching near the cortex it stimulate the initiation of formation of nodule. The division of cortex cells leads to the formation of mature nodule which makes direct vascular contact with host to nutrient exchange,

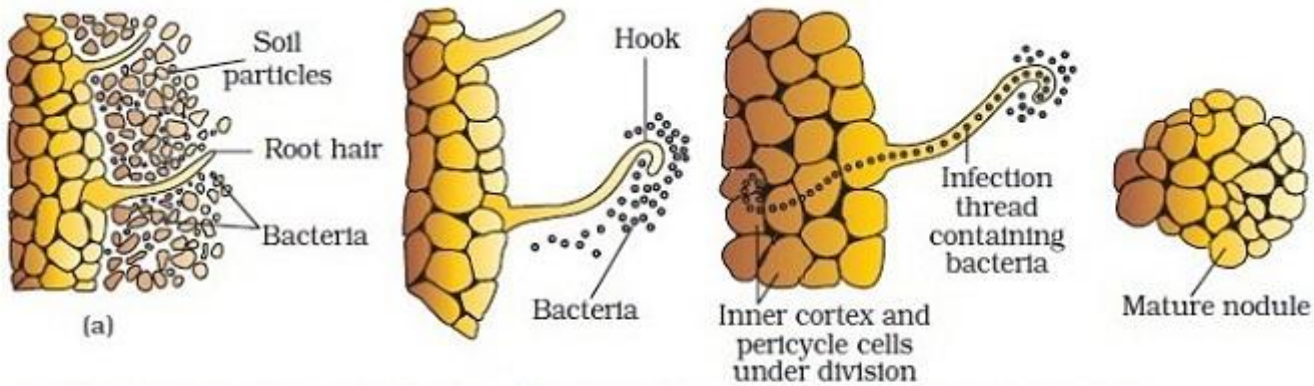


Figure 4 . Development of root nodules in soyabean : (a) *Rhizobium* bacteria contact a susceptible root hair, divide near it, (b) Upon successful infection of the root hair cause it to curl, (c) Infected thread carries the bacteria to the inner cortex. The bacteria get modified into rod-shaped bacteroids and cause inner cortical and pericycle cells to divide. Division and growth of cortical and pericycle cells lead to nodule formation, (d) A mature nodule is complete with vascular tissues continuous with those of the root

Establishing symbiosis requires an exchange of signals signaling between rhizobia and legumes is one of the best example of signal exchange identified in interaction between bacteria and their eukaryotic hosts .Plant genes specific to nodules are called nodulin (Nod) genes, rhizobial genes that participate in nodule formation are called nodulation (Nod) gene.

6.3.2Biochemistry of Nodulation and nod genes

During development of the root nodules the nodulin genes are differentially expressed. Nod factor also induces several nodules specific plant genes called noduline genes.

Reduction of nitrogen to ammonium occur in bacteroids. Nitrogenase enzyme which catalyzes this reaction is very sensitive to oxygen. In root nodules, the oxygen level is regulated by leghemoglobin.

NODULINE/NODE GENES-

The nod genes are classified as common nod genes or host specific nod genes .

1.The common nod genes- nodA, nodB, and nodC-are found in all rhizobial staines., 2.The host specific nod genes – such as nodP, nodQ and nodH,or nodF,node, and nodL-differ among rhizobial species and determine the host range.

6.3.2.1.NOD FACTOR:-

Nod factor are lipo chitooligosaccharide, the derivative of chitin. Nod factor of all studied rhizobia are beta 1,4 linked N-acetyl-D- glucosumin. Three of the nod genes (nod A, nodB, nodC) encode enzyme(NodA,NodB,and NodC, respectively) that are required for synthesizing this basic structure(stokkermanset. 1995):

1.NodA is an N-acyltransferase that catalyzes the addition of a fatty acyl chain .

2.NodB is a chitin-oligosaccrides deacetylase that removes the acetyl group from the terminal nonreducing sugar .

3.NodC is a chitin oligosaccharide synthase that links N-acetyl –D-glucosamine monomers.

There are two types of bacteria that synthesize nitrogenase and are required for nitrogen fixation .Thease are:

Free living bacteria (non-symbiotic)

Cyanobacteria , Green sulfur bacteria ,Azotobacter

Mutualistic bacteria (symbiotic).
Rhizobium, associated with leguminous plants ,Spirillum, Frankia

Previous Year Question

JUNE-2014

1.Nitrogen-fixation is basically a process of converting nitrogen gas into ammonia (NH3). One of the key enzymes in the process is nitrogenase . The production and activity of nitrogenase is very highly regulated as highlighted below

I.Nitrogen-fixation through nitrogenase is an energitiacally expensive process.
II. Nitrogenase encoding gene is under constitiutive promoter .
III. Nitrogenase is highly sensitive to oxygen .
IVEndogenous availability of the cofactor of nitrogenase enzyme is very low .

Which one of the following combinations of the above statement is/are correct?
a)I and II b)I and III

c)II and III d)II and IV

JUNE 2015

2.Symbiotic nitrogen fixation in legume nodules involves complex interaction between Rhizobium and legume roots . This complex interaction is governed by

1.Integration of sym plasmid of Rhizobium in the root nuclear genome .
2.Sensing of plant flavonoids by rhizobia .
3.Activation of nod genes in rhizobia .
4. Activation of Nodulin genes in legume roots.

Which one of the following combination is correct?

a)1,2 and 3 b)1,3 and 4
c)2,3 and 4 d)1,2 and 4

DECEMBAR-2015

1.The nodulation (nod) genes are classified as common nod genes or host specific nod genes . Some statements related to such classification are given below.

1.nodA is a common nod gene and nod C is a host specific gene.
2.nod B is a common nod gene and nodP is a host specific gene .
3.nod Q is a common nod gene and nodA is a host specific gene .
4.nod H is a common nod gene and nodQ is a host specific gene.

Which one of the following combination of above statement is/ are correct?

a)1 and 2 b)3 and 4
c)only 1 d)only 2

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	b	6.3.1
2.	2	c	6.3.1.1
3.	3	b	6.3.2.1

Sub Unit– 4

PLANT HORMONE

6.4

Hormones are numerous chemical substances that influences the growth and development of plant cells and organs .

These substance are signal molecules produced within plants that occur in extremely low concentration . they are organic compounds and are capable of influencing physiological activities leading to promotion , inhibition and modification of growth . plant hormone control all aspects of development , from embryo genesis , the regulation of organ size , pathogen defense , stress tolerance and through to reproductive development .

Example of phytohormone

1. Auxin (IAA)
2. Gibberelin
3. cytokinin
4. Ethyhene
5. Abscisic acid

6.4.1Auxin (IAA) –

Auxins were the first plant horomones to be discovered . Auxin are synthesized in the stem and roots tips and trmsported through Plant axis Auxin promote stem elongation , inhabition growth of lateral buds (maintain apical dominance). Auxin moves to the darker side of the plant ,caausing the cells there to grow longer than corresponding cells on the lighter side of the plant stem tip toword the light , a plant movement knowns as phototropism .

Nature of Auxins :

The principal auxin in plants is indole 3 acetic acid (IAA) . IAA is a derivative of amino acid tryptophan . The compounds which can be converted into auxins are called auxin precursor .

Biosynthesis and transport – two pathway for biosynthesis of IAA , these are –

1. Tryptophan – dependent
2. Tryptophan – independent

Tryptophan dependent pathway-

Total 4 tryptophan dependent pathway of synthesis –

1. 1 pa pathway (Indole – 3- pyruvate)
2. TRYPTAAMINE PATHWAY
3. IAN pathway (indole -3 – acetoninle)
4. IAM pathway

Tryptophan – independent pathway –

In this pathway of IAA synthesis starting with indole , has been partially characterized in several plant species.

6.4.1.1Auxin POLAR TRANSPORT-

Polar transport of auxin is the regulated transport of the plant hormone auxin in plants . it is an active process , the hormone is transported in cell to cell manner and one of the main feature of the transport is its directionality (polarity)

Apoplast-

Symplast

Auxin tramsport –

Auxin 1 is a transport (symplast) located randomly on plasmamebrane aux1 help in efflux of IAA. PIN 1 help in efflux of IAA and present in basal part . It is also a type of transportes . At pH- 5.6, IAA H (protonated form) is lipophilic so it can enter the plasmamembrane and cytoplasm .But in cytoplasm pH – 7 , so IAA will deprotonated itself to IAA and H+

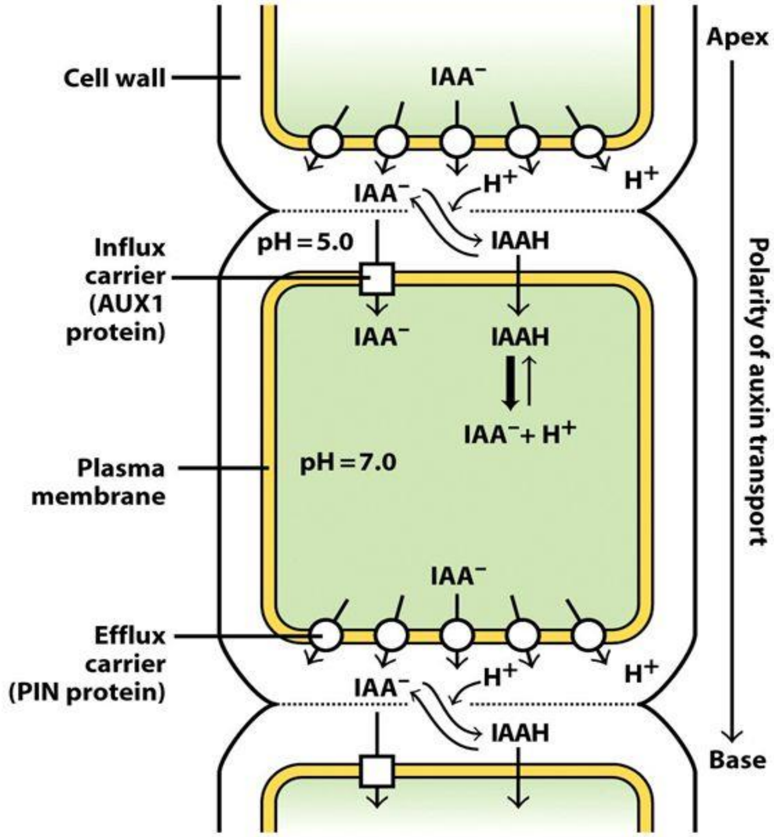


Figure 27-5
Biology of Plants, Seventh Edition

Schematic model for polar auxin transport

6.4.1.2Function of auxin

Cell growth –

It is generally agreed that auxin serves primarily to regulated cell growth and stem elongation , cell differentiation in xylem and phloem .

Axillary bud growth –

The apical bud is able to exert a dominant influence that suppresses cell division and enlargement in the axillary bud this phenomenon is unknown as apical dominance .

Root elongation and development –

Auxin enhance root elongation . high auxin concentration will promate intiation of secondary root and also adventitious roots on stem .

Parthenocarpy-

The phenomenon of fruit development in the absence of fertilization is known as parhenocorpy .It is a induction of seedless fruits by plant hormones.The three compounds used were auxin indole 3 acetic acid , indole butyric acid and napthalene acetic acid .

Example – pineapple , banana grape , orange , fruit etc.

6.4.1.3Auxin singnaling pathway –

Auxin involved in plant growth and development .It bind to intacellular receptor –TIR1(Transport inhibition Responses). Physiological effect through transcriptional regulation .Inhibition of auxin signaling Aux/IAA proteins .ARF- auxin response factor(Transcriptional activator)

TIR1(Transport inhibition Response 1)

It act as a component of the SCF, a E3 ubiqutin ligase that transfer ubiquitin molecules to the AUX/IAA proteins , targeting them for proteolysis by the 26s proteasome.

F-box Proteins

F-box proteins are proteins containing at least one F-box domain .The first identified F-box proteins is one of three component the SCF complex , which mediates ubiqutination of protein targetesed for degradation by the 26s proteasome .

ABP 1Receptor protein

ABP1 is associated with auxin r esponses at the plasmamembrane of endoplasmic reticulum including activation of proton pump and cellwall acidification and contribute to auxin regulated gene expression.

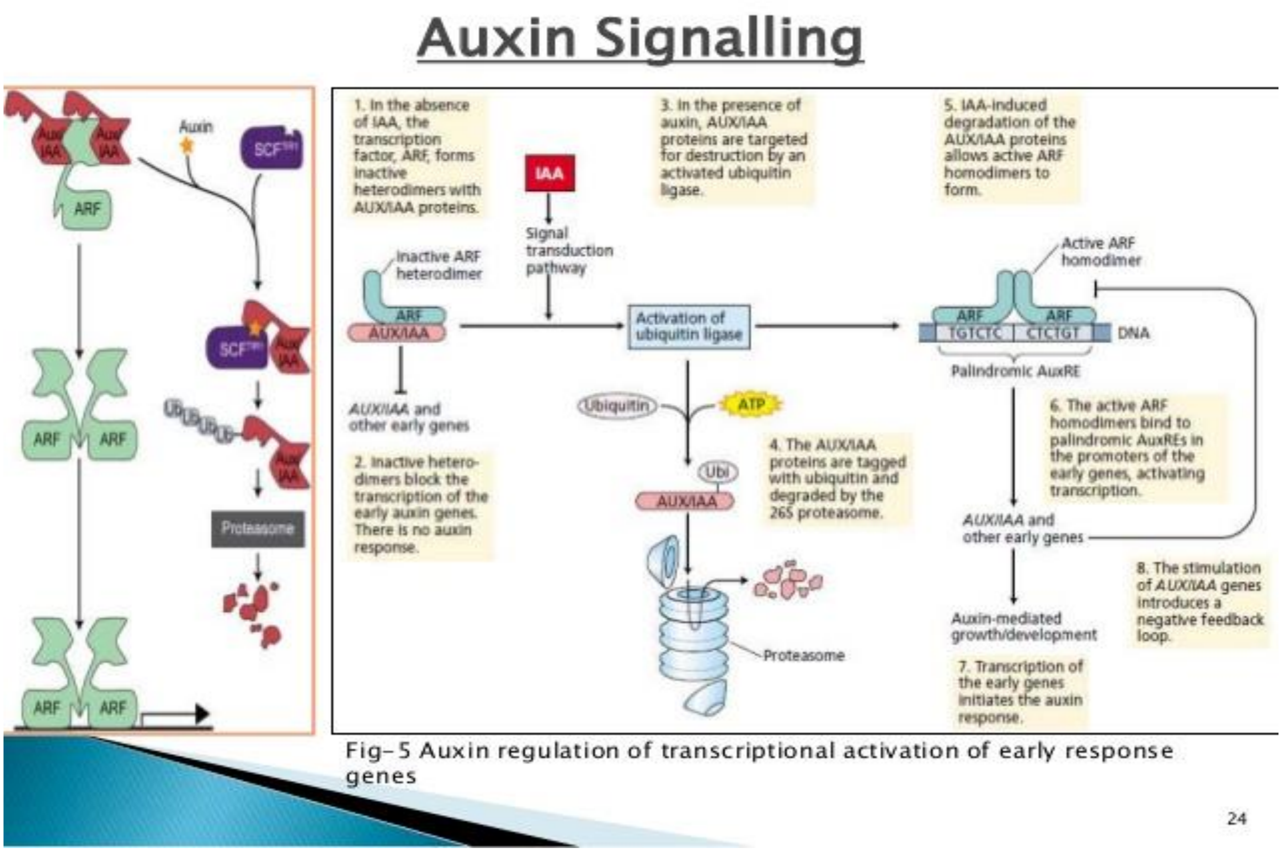


Fig-5 Auxin regulation of transcriptional activation of early response genes

6.4.2Gibberellins –

Gibberellins are plant hormones that regulate various developmental processes , including stem elongation , germination , dormancy , flowering flower development and leaf and fruit senescence. Gibberellins are produced by both fungi and higher plant .

Nature of Gibberllins-

All gibberellins are acidic in nature there are more than 100 gibberellins reported from both fungi and higher plants . They are denoted as GA1 , GA3 and soon . Gibberellic acid is a dihydroxylated gibberellins .

6.4.2.1Bio synthesis –

Precursor – Isoprenoid Unit (IPP)

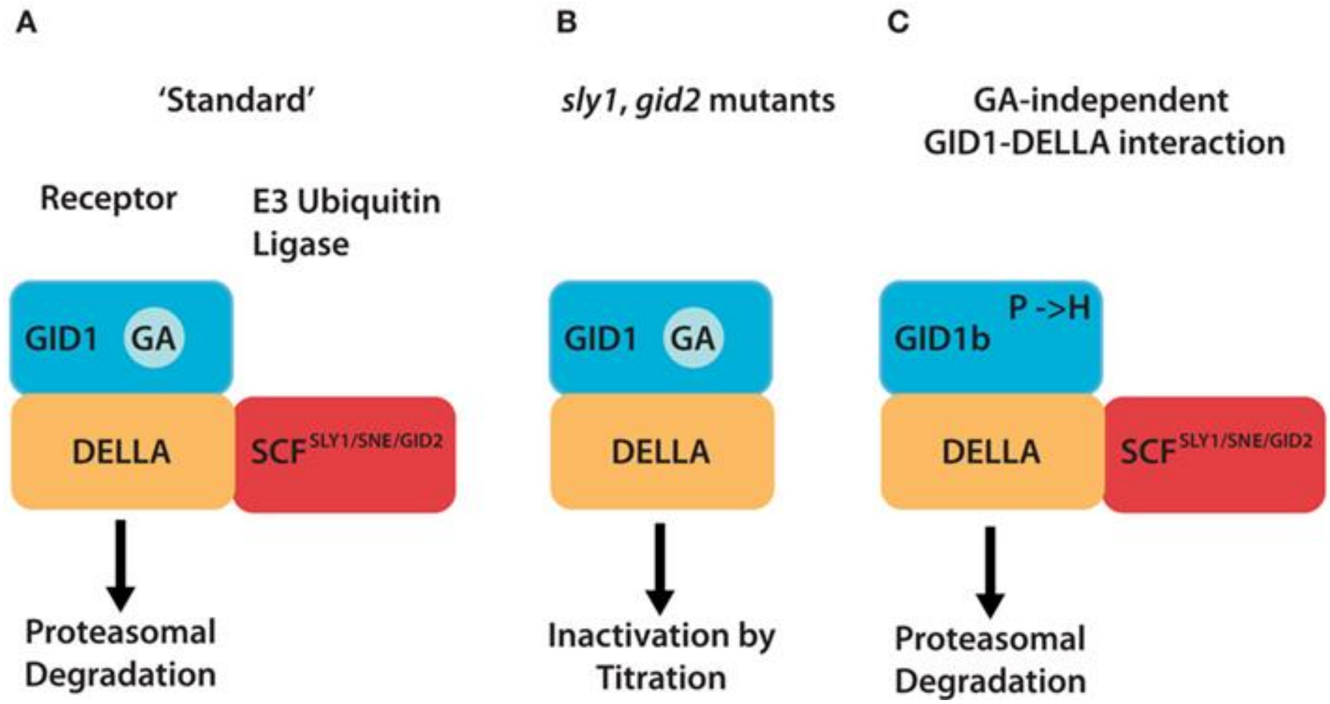
IPP – lsopentenyl pyrophosphate Biosynthesis include compartment – plastids, ER and cytosol .

GA1 is biologically active gibberellins controlling stem elongation . The precursor of GA1 in higher plants is GA20 . enzyme GA3 oxidase catalyzes the conversion GA20 to GA1 by hydroxylation of c 3 . Lack of enzyme Ga 3 oxidase caves dwarfism in plant .

Gibberellin translocation –

Gibberellins synthesize in shoot are transported to rest of the plant via phloem. Gibberellin synthesize in root are transported to shoot of the via plant via xylem . Gibberellin are capable to move in both direction , that is up and down .

6.4.2.2.Signaling pathway –



DELLA (nuclear proteins) – repressor –

DELLA proteins such as SLR1 in rice or GA1 and RGA in Arabidopsis are repressors of plant development. DELLAs inhibit seed germination , seed growth , flowering and GA reverse these effects .DELLAs proteins are characterized by the presence of a DELLA motif DELLA contain a DELLA domain and one GRAs domain .

Targets of DELLA proteins

Tramcription farter – phytochrome interactive factors (PIFs)

The first targets of DELLA proteins is PHYTOCHROME INTERACTING FACTORs (PIFs) . PIFs are transcription factors that regulate elongation growth . in the presence of GA , DELLAs are degraded and this then allow PIFs to promote elongation . It can repress transcription factors either by stopping their binding to DNA of by promoting their degradation .

Prefoldins– molecular chaperones

In addition to repressing transcription factors , DELLAs also bird to prefoldins (PFDs) . PFDs are moleculer chaperones meaning they assist in the folding of other proteins . PFDs function addition of ubiquitin to DELLA proteins promotes their degradation via the 26s – proteins release cells from their repressive effects .

6.4.2.3Function

Seed germination-

Gibberellins induce the production of enzymes like amylases, proteases ,lipases and ribonuclease for mobilizing storage reserves during seed germination and early seedling growth .

Flowering –

Many perennial plants, must achieve a minimum stage of development before they are capable of flowering in the cytosol but when DELLAs bind to PFDs , it restricts them to the nucleus . An important function of PFDs is to assist in the folding of B- tubulin .

Receptor

GA INSENSITIVE DWARF 1 (GID1)- soluble receptor

GA binding to GID1 cause changes in GID1 structure , results in the exposure of a surface which enables the binding of GID1 to DELLA proteins.

Mechamism –

When GA binds to the GID1 receptor , it enhance the interaction between GID1 and DELLA complex . it is thought that DELLA protein undergo change in structure that enable their binding to F-box proteins . F box protein catalyse the .

6.4.3Cytokinins

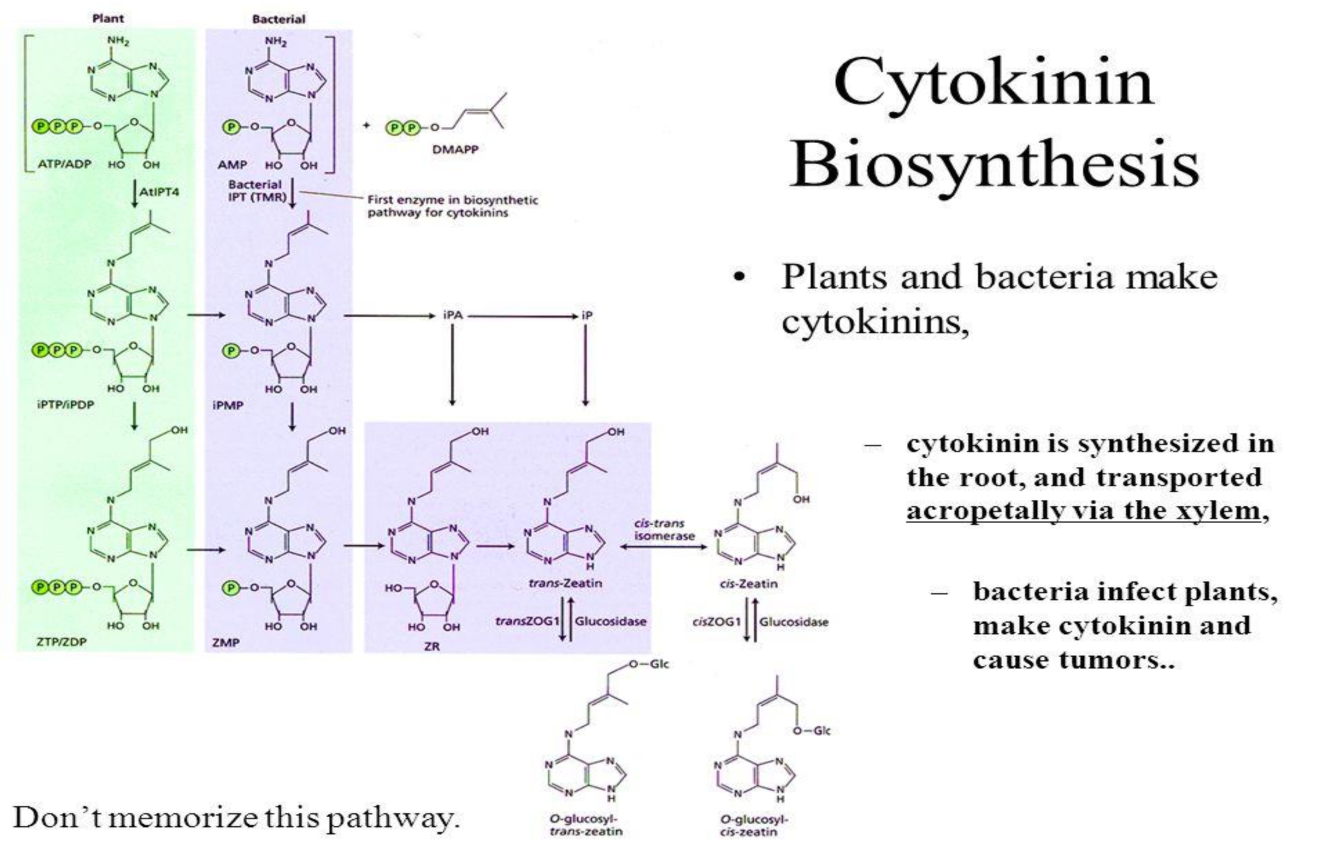
Cytokinins have a specific effects on cytokinesis that is cell division. Kinetin does not occur naturally in plants. The most wide spread naturally occurring cytokinins in higher plants is zeafin . Cytokinins (ck) are plant growth hormones which are basic in nature. Kinetin does not occur naturally. It is is a synthetic hormone. The first natural cytokinin was obtained from unripe maize grain known as zeatin. It also occur in coconut milk.

Biosynthetic location

Roots seems to be the major source of cytokinin synthesis. From roots the cytokinins pass upwardly through xylem. Some cytokinin synthesis also takes place in other areas where cell divisions are occurring like endosperm region of seeds ,growing embryos and developing seeds ,young fruit,developing shoots, buds etc. Coconut milk is rich source of cytokinin.

6.4.3.1Biosynthesis

The first committed step in cytokinin biosynthesis is the addition of the isopentenylside chain from DMAPP to an adenosine moiety. The plant and bacterial IPT enzymes differ in the adenosine substrate used ,the plant enzymes appears to utilizes AMP. The products of these reaction are convert to zeatin by an unidentified hydroxylase.



6.4.3.2Function

Cell division:

Cytokinins are noted primarily for the ability to induce cell division in plant tissue and cell culturally. Many cells may be induced to undergo division when cultured on artificially media containing cytokines.

Morphogenesis:

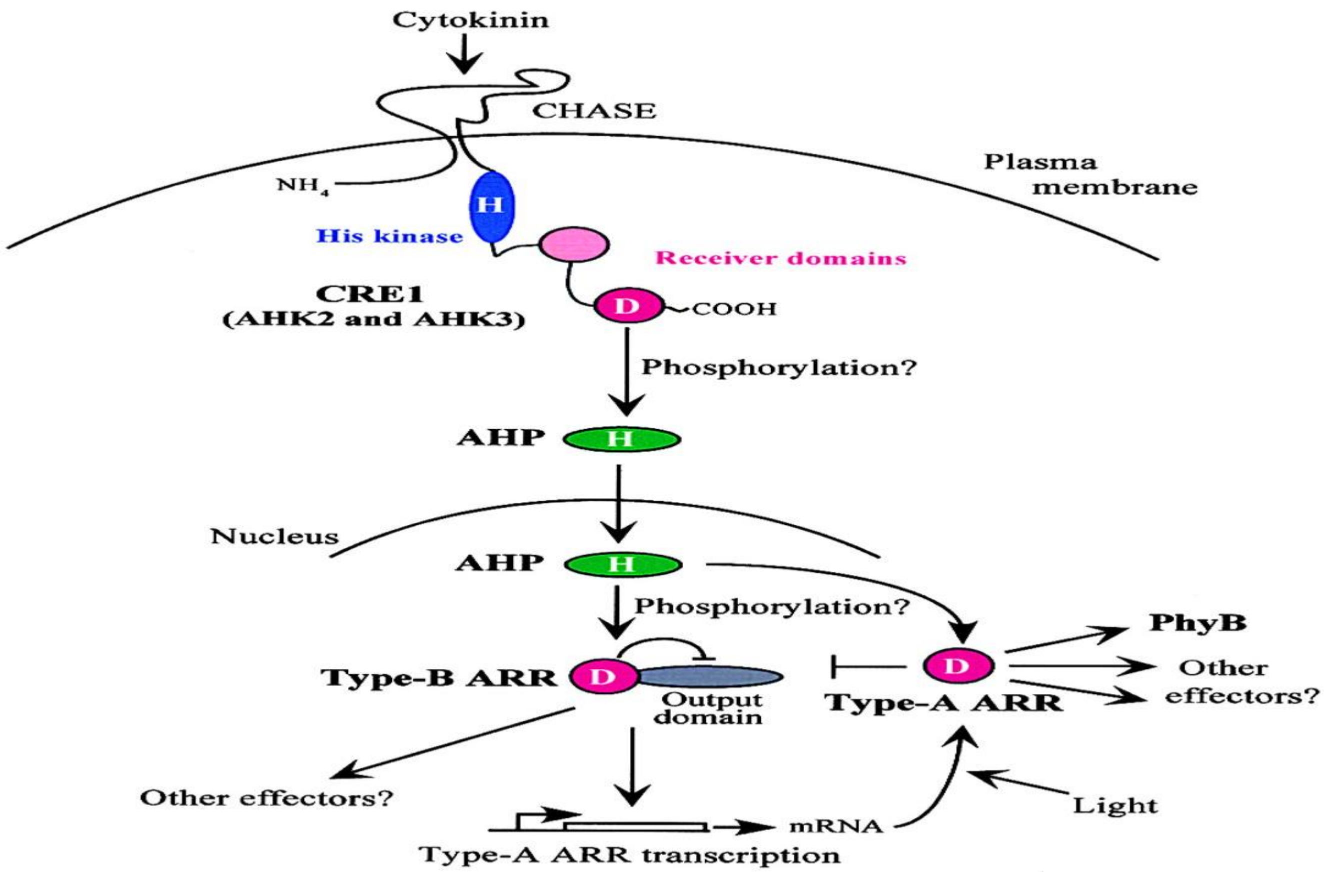
Cytokinin also influence morphogenesis in the cultured tissues. High molar concentrations of cytokinin to auxin tend to induce bud development ,while high ratios of auxin to cytokine will encourage root development.

Apical dominance

The application of cytokinin stimulate release of axillary buds from apical dominance thus reversing effect of auxin.

6.4.3.3.Cytokinins signaling pathway

The cytokinin receptor are encoded by a multigene family. Receptor CRE1(cytokinin response 1) contain a conserved extra- cellular cytokinin binding domain called the CHASE domain .Receptor in Arabidopsis for CK signaling –AHKs(AHK2,AHK3 and AHK4),CHASE domain bind to cytokinin in pH dependent manner. Histidine phosphotransfer protein proteins are predicted to mediate the phosphotransfer between sensor kinase and response regulators.



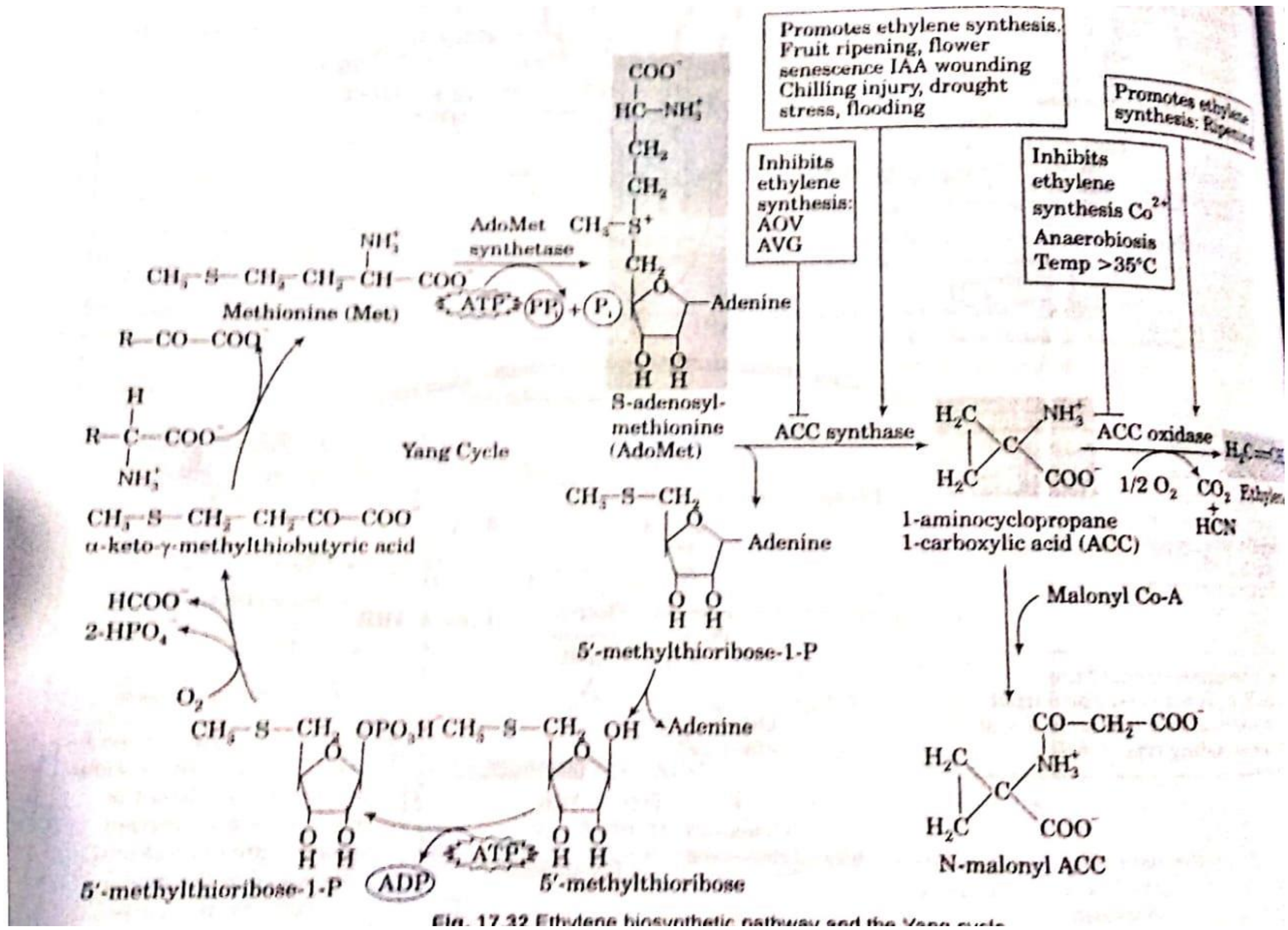
6.4.4.Ethylene

Ethylene is simple gaseous hydrocarbon with the chemical structure CH_2=CH_2 .Ethylene is a natural product of metabolism in plants. Ethylene appears to be synthesized in response to stress. Ethylene is a gaseous hormone that forms through the breakdown of methionine which is in all cell. Ethylene is produced at a faster rate in rapidly growing and dividing cells ,especially in darkness.

6.4.4.1Biosynthesis

The amino acid methionine is the Precursor of ehelene . The rate –limiting step in the conversion of

AdoMet to ACC, which is catalyzed by the enzyme ACC synthase .The last step in the pathway , conversion of Acc to ehelyne required oxygen and is catalyzed by the enzyme ACC oxidase.



<u>Fig – Ethelene biosynthesis pathway</u>

<u>6.4.4.2Function</u>

Vegetative development

Ethylene has been shown to stimulate elongation of stems ,petioles, rrots and floral structure of aquatic and semi aquatic plants.

Fruit Development

A variety of fruits like banana .apples. release ethylene gas during ripening. Ethylene is auto catalytic that is ethylene released by ripening fruits will in turn stimulate maturation and ethylene production by other fruits stored nearby.

Apical dominance

Ethylenes promotes apical dominance and prolong dormancy of lateral buds.

Apo geotropism

It decrease the sensitivity to gravity. It promotes Apo geotropism in roots.

Senescence

It increases the speed of senescence of leaves and flower.

Abscission

Abscission of various part(leaves,flowers ,fruits) is stiumulated by ethylene which induces the formation of hydrolases.

6.4.4.3Ethylene Triple Response

From a genetic standpoint , exposure of dark grown of germinating of Arabidopsis to ethylene cause.

1.Short/reduced hypocotyl (stem elongation).

2.Increase in width of stem (radial swelling of the hypocotyl).

3.Tightening of Apical hook (curl) or horizontal growth of epicotyl with respect of gravity.

Ethylene insensitive mutants

Mutants that fail to response to exogenous ethylene (ethylene resistant) insensitive mutants that do not show a triple in the presence of ethylene.

Example -ETR1,EIN2 , EIN3

Constitutive mutants

Mutants that display the response in the absence of ethylene .

Example -CTR1.

6.4.5Abscisic Acid

Abscisic acid is a simple compound , involved in regulating seed germination
Inducing protein synthesis and modulating water stress.
Abscisic acid Promotes leaf fall and dormancy of buds ,Abscisic acid reverse the
Effect of gibberelines .It is regarded as the stress hormone.ABA is synthesized in vascular tissue of leaves.

6.4.5.1Biosynthesis of ABA

ABA biosynthesis takes place in chloroplasts and other plastids. The pathway with isopentanyl diphosphate (IPP), the biological isoprene unit and leads to synthesis of C40 xanthphyll and violoxanthin.

6.4.5.2.Function-

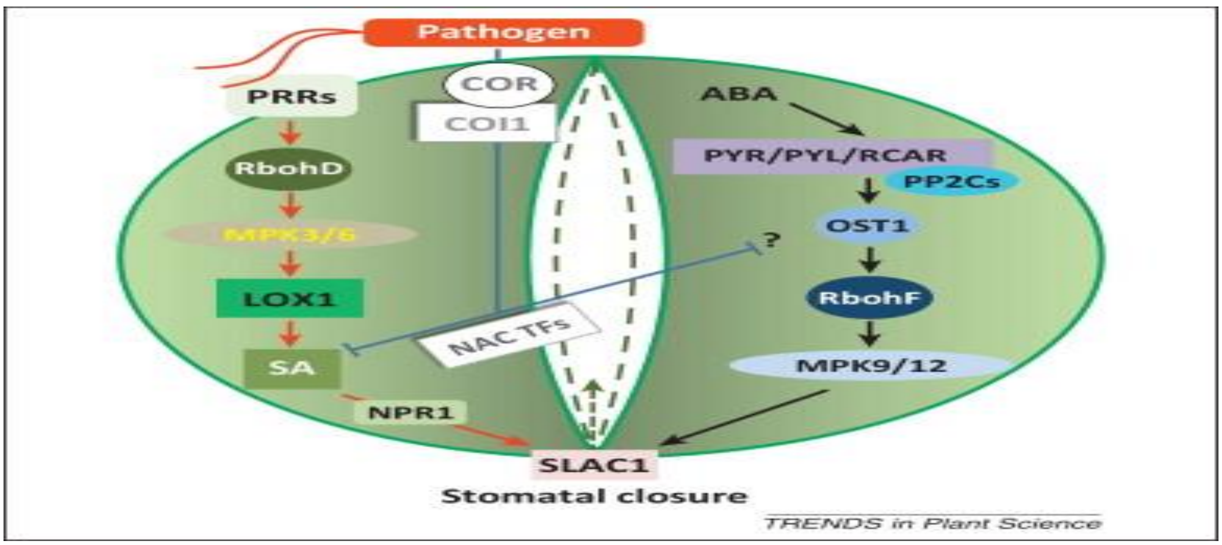
Abscisic acid promotes leaf fall and dormancy of buds in the seed coat causes dormancy.

ABA decreases the synthesis of RNA and protein in the leaves enhancing the formation of absicission zone which the leaf to detached.

Inhibit stomatal opening and promote root growth .

<u>6.4.5.3.ABA signaling in stomatal closure</u>

ABA closes stomata in response to water stress .ABA concentration in leaves can increase up to 50 times under drought conditions .Redistribution or biosynthesis of ABA is very effective in causing stomatal closure and its accumulation in stressed leaves plays an important role in the reduction of water loss by transpiration under water stress condition. Stomatal closing can also be caused by ABA synthesized in the roots and expoted into the shoot.



Previous Year Question

DECEMBAR-2015

1.Many factors related to the role of abscisic acid (ABA) in contributing to drought, cold and salt resistance in plants are listed below:

A. The transcription factors DREB1 and DREB2 bind to the cis-acting elements of the promoter of ABA-responsive genes in an ABA-dependent manner.

B. ABA induces many genes such as LEA and RD29.

C. ABA-responsive genes contain six- nucleotide ABRE elements in the promoter.

D. Nine-nucleotide dehydration-responsive elements (DRE) are present in ABA- responsive genes.

Which one of the following combinations of the above statements is correct with respect to ABA?

1. A, B and C   2. A, C and D
3. B, C, and D   4. A only

2.Examples of many factors that regulate plant height in response to gibberellic acid (GA) are listed below:

A. Binding of a GA-bound repressor to the promoter of the DELLA domain- containing GRAS protein gene and blocking its expression.

B. Binding of the GA-receptor complex to GRAS.

C. Directing GRAS for ubiquitination and degradation by the 26S proteasome.

D. Micro RNA directed down regulation of the GRAS protein expression.

Which one of the following combinations is correct?

1. A and B   2. B and C
3. C and D   4. A and D

3.Ethylene is an important plant hormone that regulates several aspects of plant growth and development. Some statements are given below in relation to ethylene signalling pathways:

A. Unbound ethylene receptors work as positive regulators of the response pathway.

B. There are more than two ethylene receptors known to date.

C. The carboxy-terminal half of the ethylene receptor, ETR1 (Ethylene-response 1), contains a domain homologous to histidine kinase catalytic domain.

D. EIN2 (Ethylene-insensitive 2) encodes a transmembrane protein. The ein2 mutation promotes ethylene responses in both seedlings and adult Arabidopsis plants.

Which combination of the above statements is correct?

1. A and B
2. B and C
3. C and D
4. D and A

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	3	6.4.5
2.	2	2	6.4.2
3.	3	2	6.4.4

JUNE-2016

1.Which one of the following plant hormones use the two-component histidine kinase receptor system for signal transduction?

1. Auxin 2. Gibberellin
3. Cytokinin 4. Abscisic acid

2.The following statements are made to describe auxin signal transduction pathway, from receptor binding to the physiological response:

I. Auxin response factors (ARFs) are nuclear proteins that bind to auxin response elements (Aux REs) to activate or repress gene transcription.
J. AUX/IAA proteins are secondary regulators of auxin-induced gene expression. Binding of AUX/IAA proteins to the ARF protein blocks its transcription regulation.
K. Auxin binding to TIR1/AFB promotes ubiquitin-mediated degradation and removal of AUX/IAA proteins.
L. Auxin binding to auxin response factors (ARFs) causes their destruction by the 26S proteasome pathway.

Which one of the following combinations of above statements is correct?

1. A, B and C 2. A, C and D 3.B,C and D 4.A,B and D

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	3	6.4.3
2.	2	1	6.4.1.3

Sub Unit– 5

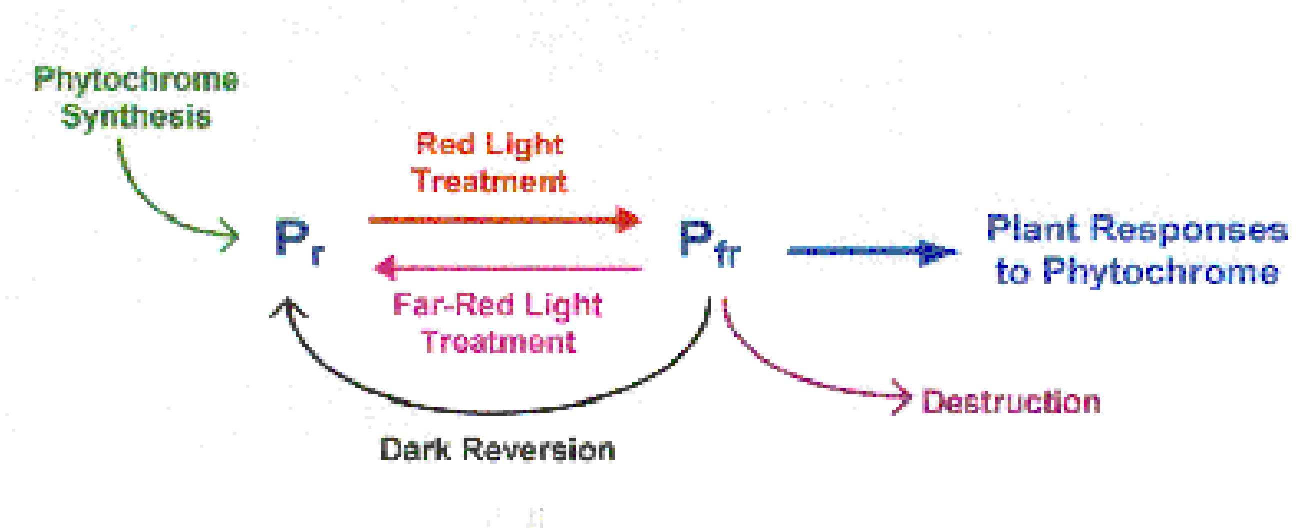
SENSORY PHOTOBIOLOGY

6.5Photomorphogenesis

Light is important role in photosynthesis,but also painful for plant growth and development. The light-mediated Change in plant growth and development ,are called photomorphogenesis.

In photomorphogenesis light act as a Signal intiate and regulation . Three major photoreceptor involved in photomorphogenesis, these are -

1. phytoChrome
2. Cryptochrome
3. Phototropin



6.5.1 Phytochrome

It is a photosynthetic Pigment that absorb red and far-red light and Course photomorphogenesis. Phytochrome found in most plant, regulate growth and development Process like induction regulate of flowening, seed germination, stem elongation . It consist of chromophore which is also called phytochromobilin

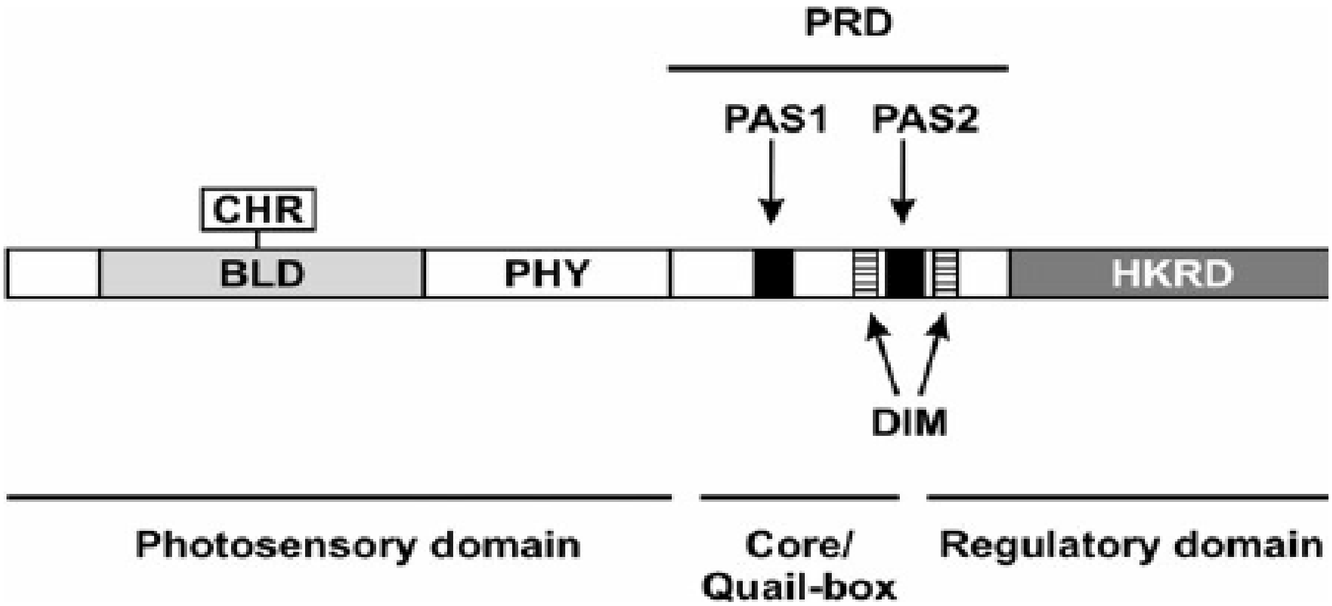


Fig-Structural domain in phytochrome

The phytochrome Pigment is found to be present in two photo reversible forms:

1. Red light absorbing (666 nm) Pr forms

2.far- red light absorbing (730 nm) Pfr form

6.5.1.1. Classes of phytochrome -

Type-1 phytochrome is light sensitive so in light the transcription of PHY gene inhibited , mRNA degradation and Proteolysis takes place. Type I plastochron mainly tuition tn dark,

Example - PHYA

Tspe-2 phytochrome light stable, so Present in both Light grown and dark grown plants. Type -1 phytochrome mainly function in light.

Example- PHY-B, PHYC, and PHYE

PHY B is most abundant in light grown plant and PHYC -PHYE less abundant.

6.5.1.2 Mode of action of phytochrome

CONSTITUTIVE PHOTOMORPHO GENE- I (COP-1)

Cop-1 is a E3 Ubiquitin ligase, which are involved in targeting Proteins for 26S Proteasome -mediated degradation. It inhibit the photomorphogenesis in dark by degrading the the phytochrome inducing factor (PIFS).

In the dark, cop 1 is present in the nucleus, but in the light it is only found in the cytoplasm.

HY5 – HY5 is a transcription factor tha is a photomorphogenesis in phytochrome pathway. In the light, the level of HY5 protein increase and in the dark it declines.

6.5.2 Cryptochrome –

Cryptochrome is a chromoprotein, .It is a blue Light photo receptor of plant .The word cryptochrome means hidden color.The chromophore for cryptochrome is Flavin and Pterin .Three common Flavins are - riboflavin and its derivatives, FMN and FAD . cryptochrome is a Flavoprotein. Cryptochromes generally found in all plant species.

6.5.2.1 CRYPTOCHROME SPECIAL PROPERTY

Cryptochrome play in important role in the generation and maintaince of Circadiam rhythm. Cryptochrome are structurally similar to photolyases. Photolayses is a blue light activated enzymes

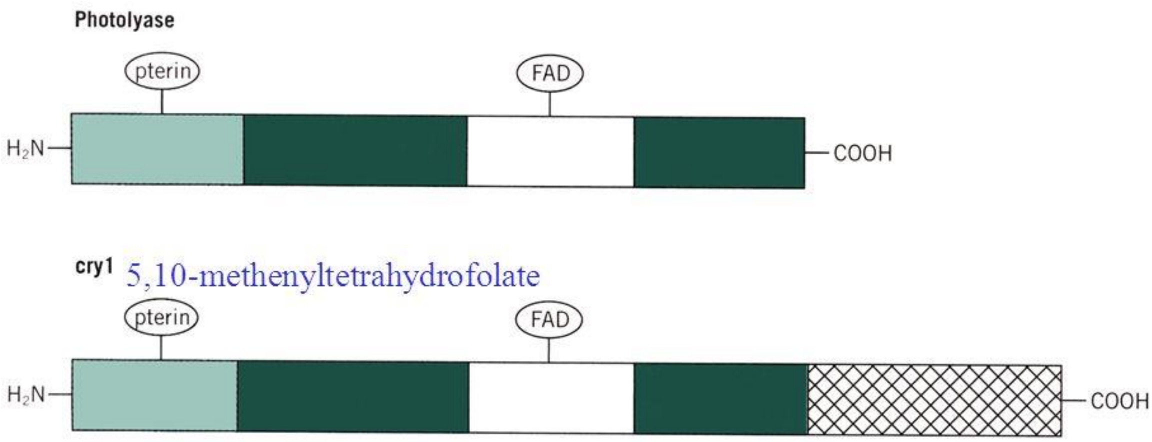
that repairs pyrimidine dimer DNA.

6.5.2.2 Function of Cryptochrome

Crypto chrome importent role in plant that circadian clock, and also stomatal opening . It is also

Stimulate in photomorphogenesis, inhibition of stem elongtion etc.

Cryptochrome is a flavoprotein



2 Cryptochrome Genes

Three type of crypto chrome in Arabidopsis thalima Cry 1, cry 2 and cry 3 genes are present in Arabidopsis (plants). CRY2 show a large increase in the blue light - Stimulated cotyledon expension cry 1and cry2 is nuclear gene. Cry3 is chloroplast and mitochondrial gene. Light stable - cry 1 and cry3, CRY1 and CRY2 have been shown to play a role in the induction of flowering Cryptochrome. CRYI has been shown to be involved in the setting of the circadian clock in Arabidopsis .

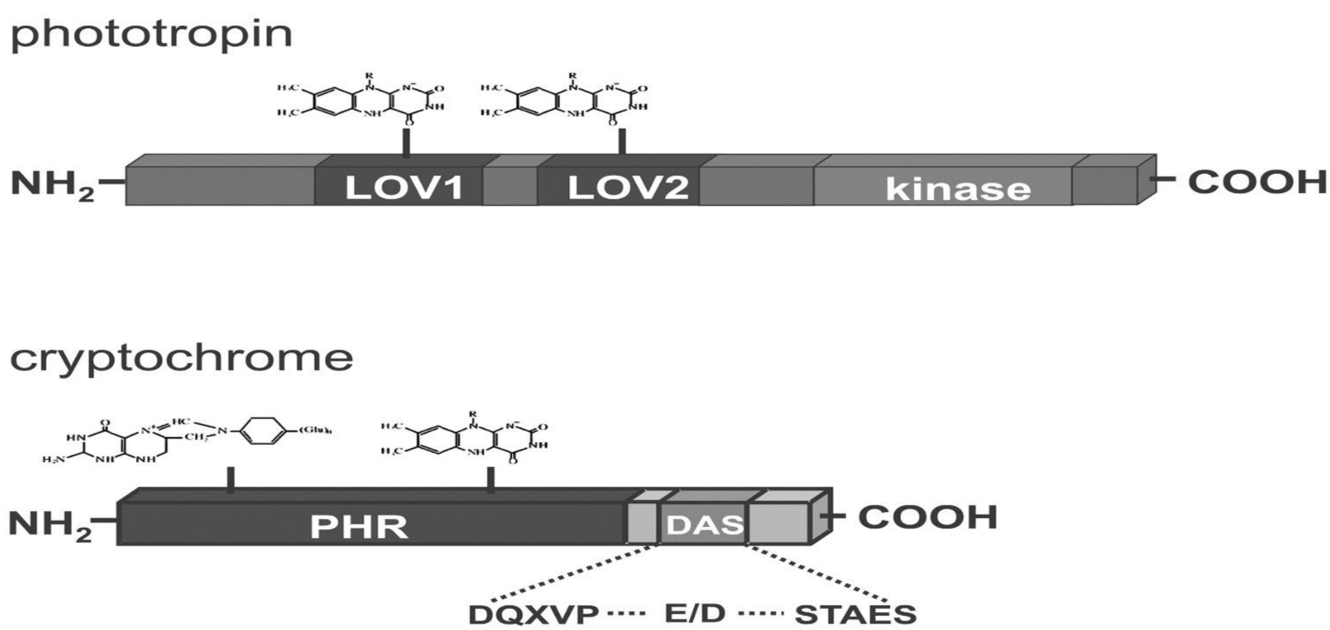
6.5.3Phototropin

Photropin is a flavoprotein which act as a blue light photo receptor. They are light activating serine (threonine Protein Kinases.This include phototropism, light induced Stomatal opening and chloroplast movement in response to change in light intensity.

Phototropin Genes

The phototropin has a major role in regulation of phototropism and chloroplast movements . There are two different Phototropins in Arabidopsis that exists overlapping function in addition to having Unique physiological role. The two Phototropins are phot 1 and photo2. photo 1 help in collection/hypocotyl growth.

<u>Structural Domain of phototropin</u>



1 Phototropin contain two light sensing light –oxygen –voltage (LOV) Domains , LOV1and LOV2.

2 LOV1 and LOV2 bind a chromophore .

3 Blue light irradiation /photoexitation of protein bound FMN cause a conformation change of phototropin that triggers auto phosohorylation and start the sensory transduction cascade(phototropin signaling).

6.5.4Phototropism

phototropin mediate the auxin gradient Change in plot in light. The plant will bend towards the light.The darker side will have high concentration of auxin as compare to light side rapid cell division and elongation at darker side due to high concentration of auxin

Chloroplast movement

Chloroplast movement in leaves is a adaptive features that occur in order to control light absorption and Prevent photo damage.

case-1. IN Low Light intensity

when Incident radiation is low, (low light intensity), chloroplast, moves at the Upper and Lower Surface of mesophyll cells to maximise the light absorption. Maximum light harvesting by chloroplast accumulation.

Case -2 IN High light intensity

Under high intensity of light , the chloroplast moves to the cell surface that are parallel to the incident light , thus to minimum the light absorbtion . Protection from strong light .

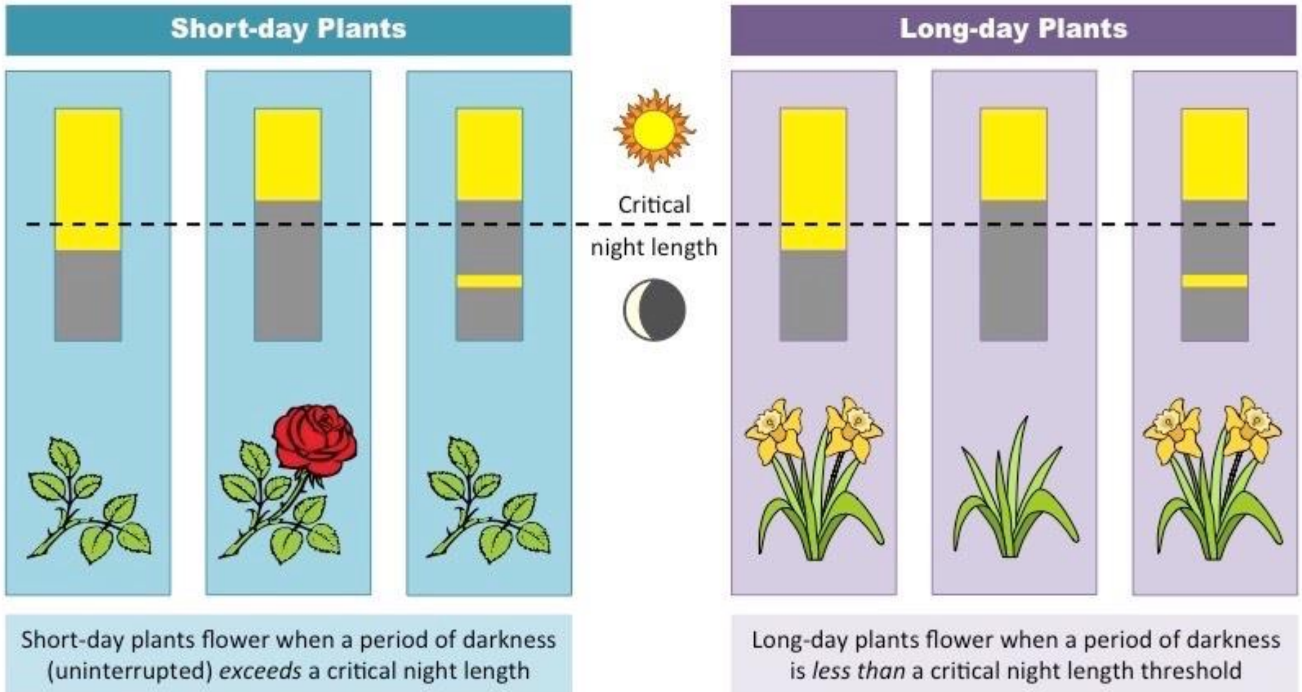
Photoperiodism

Photoperiodism is the response of the plants to measure the length of Photoperiods .Garner and Allard were the first to use the term photoperiodism . They observed that Maryland mammoth variety tobacco failed to produce flowers during summer but when grown in green house during winter the plant flowered profusely .

6.5.3.1Plants can be Classified into following types based on 24 hour cycle and darkness

• **Short-day plants**: These plants flower When length is shorter than a certain 'critical Period' under photoperiods longer then a critical point these plants will not flower .

Example- Canabids sativus , Nicotina tabaccum, Glycine max etc.



• **Long day, plants**:

These plants flower when day length is longer then a certain Critical period Under Photoperiod shorter than a critical point these plants will not flower.

Example: plantago lanceolata, Beta vulgaris etc..

• **Indeterminate (Day-neutral).**

These plants flowers over a wide range of daylenth from relatively short photoperiods to continuous illumination.

Example: Lycospersicum esculentum (tomato)Mirabilis, Capsicum annuum

• **Intermediate plants:**

These plants flower only under daylengths within a certain range usually between 12-16 hours of light but fail to flower Under either longer or shorter photoperiods.

Ampbiphotoperiodic plants:

such plants remein vegetative intermediate day length and flower only on shorter or longer daylengths, for example , Madia elegans.

*** Short -long day plants** :

These plants flower when short photo periods are followed by long photoperiods, for example, some varites of Triticum vulgare , secale cereal.

Critical Period

For short day plants the critical Period is the photoperiod at or below which a short day plants will flower and for long day plants the critical period is the photo period at or above which a long day plant will flower.

Previous Year Question

DECEMBARN 2014

1.Light is crucial for plant growth and development .Following are certain statements related to photoreceptor in model plant Arabidopsis thaliana .

1. Among the five phytochrome genes , representing a gene family ,(PHYB)plays a predominant role in red light perception
2. Cryptochromes are involved in the regulation of flowering time and hypocotyl length.
3. phy A photoreceptor is predominantly involved in far red light perception
4. The LOV domain of phytochrome C (PHYC) is an important domain for signal transmission

Which one of the following combination of above statement is /are correct?

a)1,2 and 3
b)1,3 and 4
c)2,3 and 4
d)1,2 and 4

JUNE-2015

2.Light is an important factor for plant growth and development . There are several photoreceptor in higher plant such as Arabidopsis thaliana involved in perception of various wavelength of light .Some statements are given below related to photoreceptors

1. Red light photoreceptors are represented bya gene family
2. phytochrome C is most prominent photoreceptor to perceive red light
3. Cryptochrome 1 and cryptochrome 2 have evoloved from bacterial DNA photolyses
4. Far-red light is perceived by phytochrome D.

Which one of the following combination of above statement is /are correct?

a)1 and 2
b)2and 3
c)3 and 4
d)1 and 3

3.Phytochrome-mediated control of photomor- phogenesis is linked to many other gene functions. The following statements are made on the mechanism of phytochrome action:

A. Phytochrome function requires COP1, an E3 ubiquitin ligase that brings about protein degradation

B. COP1 is slowly exported from the nucleus to the cytoplasm in the presence of light

C. HY5 is targeted by COP1 for degradation in the presence of light

D. HY5 is a transcription factor involved in photomorphogenetic response

Which one of the following combinations is correct?

1. A, B and C
2. B, C and D
3. A, B and D
4. A, C and D

<u>Answer with Reference</u>

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	a	6.5.1, 6.5.2,
2.	2	d	6.5.1
3.	3	3	6.5.1

Sub Unit– 6

Solute Transport and Photoassimilate Translocation

6.6.Solute Translocation

Movement of some inorganic ions and some organic compounds, insoluble formfrom one place to another in higher plants is called as translocation of organic solutes large scale transport between plant and environment or between leaves and roots, is also controlled by membrane transport at the cellular level. For example the transport of sucrose from leaf to root through the phloem, reffered to as tramslocation. Source is that part of the plant that synthesize the food, i.e., leaf and sink is that part of the plant, the part that needs or stores the food. The source sink relationship is variable. The direction of movement in the phloem can be upward or downwards i.e.bidirectional.

Active absorption of water:

The first step of absorption of water is the imbibition of soil water by the cell surface of root hairs. Plasma membrane being differentially permeable membrane allow solvent against gradient but not salute. The osmotic potential (OP) plays on important role in the absorption of water.The water molecule move from the side of less osmotic potential of water.

Passive absorption of water

It is mode of water absorption in which the force develops in the shoot system where transpiration is going on. Transpiration creates negative pressure in the xylem due to loss of water from the aerial parts. The negative pressure occurs in the xylem sap as water does not split out if a cut is given to a shoot. There are three pathway water movement in root.

Apoplast Pathway

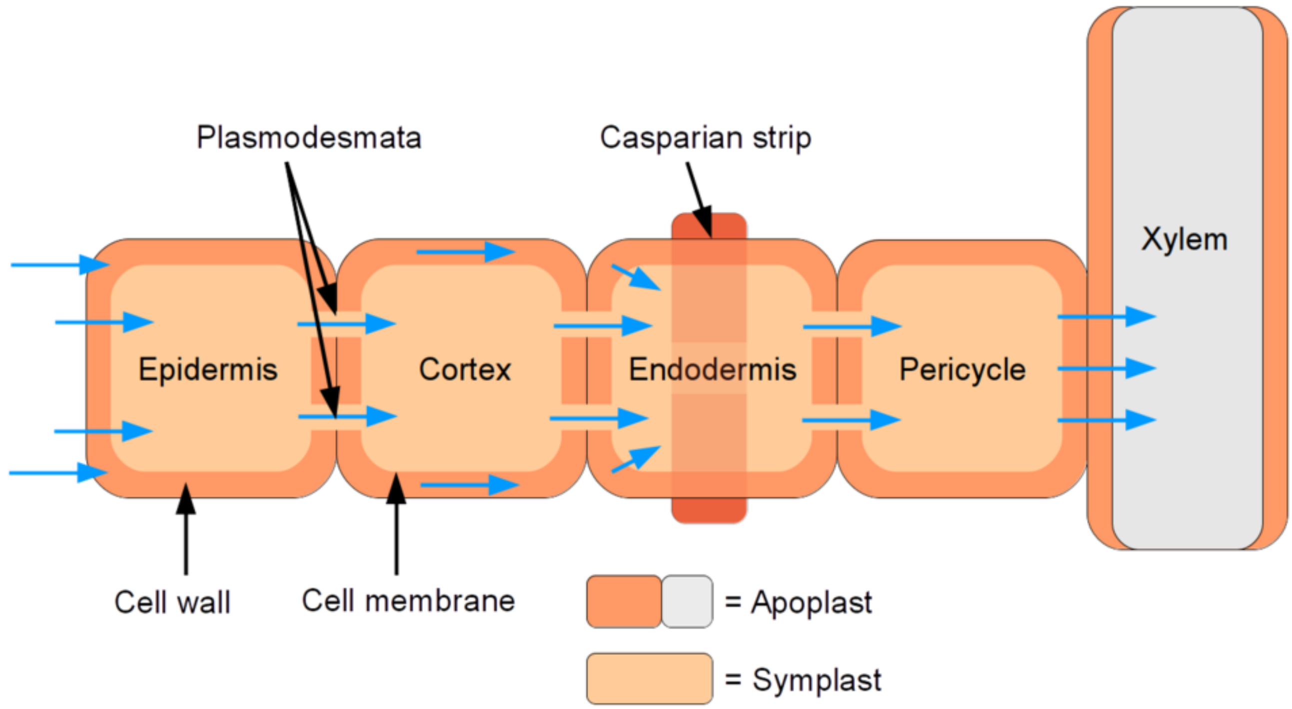
Movement of water takes place in the space between the cell and in the cell walls themselves.

Symplast Pathway:

Movement of water takes place from one cell to another by plasmodesmata.

Transmembrane Pathway

Water across atleast two membrane

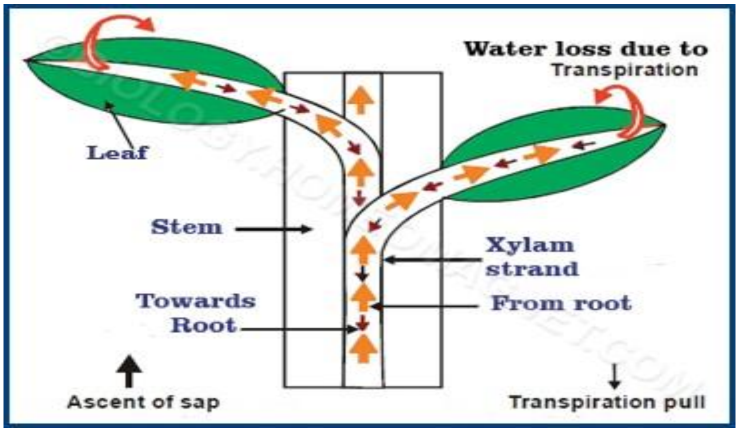


6.6.1 Ascent sap

The upward movement of water through stem is called as ascent sap . The sap (i.e water with dissolve minareles) is absorbed mainly by roots and is moved up to all the plant via stem ascent of sap are types of theories to explain ascent of sap.

6.6.1.1.Transpirational pulls cohesion of water theory

Cohesive and adhesive properties of water molecules to form an unbroken continuous water coloum in the xylem .Trans piration pull or ntension exerted on this water upward through the xylem in the plants can achieve fairly high rate .



Means of transport /uptake

Diffusion:-Molecules of gases , liquid and solutes moves from the higher concentration of lower concentration is known as diffusion .

Facillated diffusion:-is a process by which molecules are transported across the plasma membrane proteins .It takes place without the expenditure of energy . Membrane protein are specific for the substances through being transported.

Types of Faccilated diffusion –

1. **Uniport-**

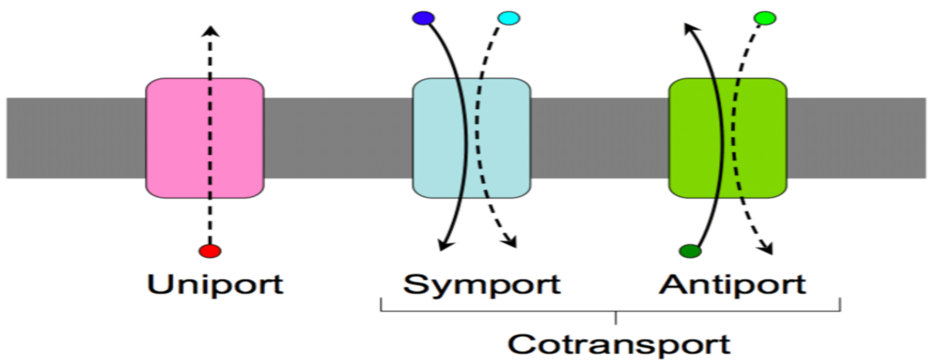
   A protein involved in moving only one molecule across amembrane .

2. **Symport** –

   Proteins that move two molecules in the same direction across the membrane .

3. **Antiport-**

   If two molecules are moved in opposition direction across the membrane .



Osmosis-

The diffusion of solvent from a hypotonic solution (having lower concentration) to hypotonic solution (having higher concentration) through a semipermeable membrane to keep the concentration in equilibrium.

<u>6.6.2Pressure Flow Model –</u>

This model describe the movement of carbohydrates in phloem . Dissolved carbohydrates flow from a source and are released in sink .Sink include growing root and stem tips as well as developing fruits .

Two steps in translocation require metabolic energy

i)Transport of sucrose and other solutes into the sieve tubes at source , called loading .

ii)Removal of the solutes , called unloading ,where the sieve tubes enter sinks .

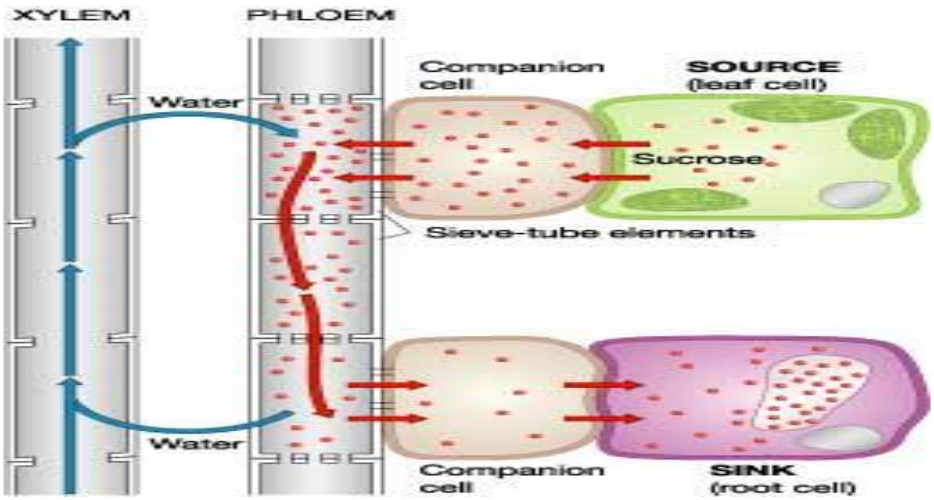


Fig- Pressure flow hypothesis model

According to this model translocate in the phloem , sucrose is actively transported into sieve tube elements at a source , giving those cells a grater sucrose concentration than the surrounding cells . In the sink , the source is unloaded by active tansport , maintaining the gradients of solute for movement.

Previous Year Question

DECEMBAR 2016

1.Which one of the following best describes the symplast pathway of water flow from the epidermis to endodermis in a plant root?

1. Water moves through cell walls and extracellular spaces without crossing any membrane
2. Water travels across the root cortex via the plasmodesmata
3. Water crosses the plasma membrane of each cell in its path twice, once on entering and once on exiting
4. Transport across the tonoplast

2.Given below are statements describing various features of solute transport and photoassimilate translocation in plants.

A. Apoplastic phloem loading of sucrose happens between cells with no plasmo- desmatal connections
B. Growing vegetative sinks (e.g., young leaves and roots) usually undergo symplastic phloem unloading
C. Movement of water between the phloem and xylem occurs only at the source and sink regions
D. Symplastic loading of sugars into the phloem occurs in the absence of plasmodesmatal connections

Select the option that gives a combination of correct statements:

1. Only A and C
2. Only B and C
3. Only B and D
4. Only A and B

Answer with Reference

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	1	2	6.6
2.	2	4	6.6.1

Sub Unit– 7

SECONDARY METABOLITES

6.7 Plants are synthesized different types which may be divide two main groups primary and secondary metabolites are compounds which are not essential for normal growth .Secondary metabolites are required for plant survival and help in response to stress. Secondary metabolites are four major class these are-

1)Terpene

2)Phenolics

3)Alakaloids

4Glycosides

1.Terpenes

Terpenes or terpenoids constitute a large classes of the secondary product . Terpenes technically hydrocarbon while terpenoids, are oxygenated hydrocarbon .Terpene are formed of five carbon isoprenoid, units. The basic structure of terpenes are generally called isoprenoid unit.

6.7.1Biosynthesis pathway-

Biosynthesis of terpenes generally two pathway these are –

1.MVA(Mevalonic acid pathway)
2.MEP(Methyl Erythiosis phosphate pathway)

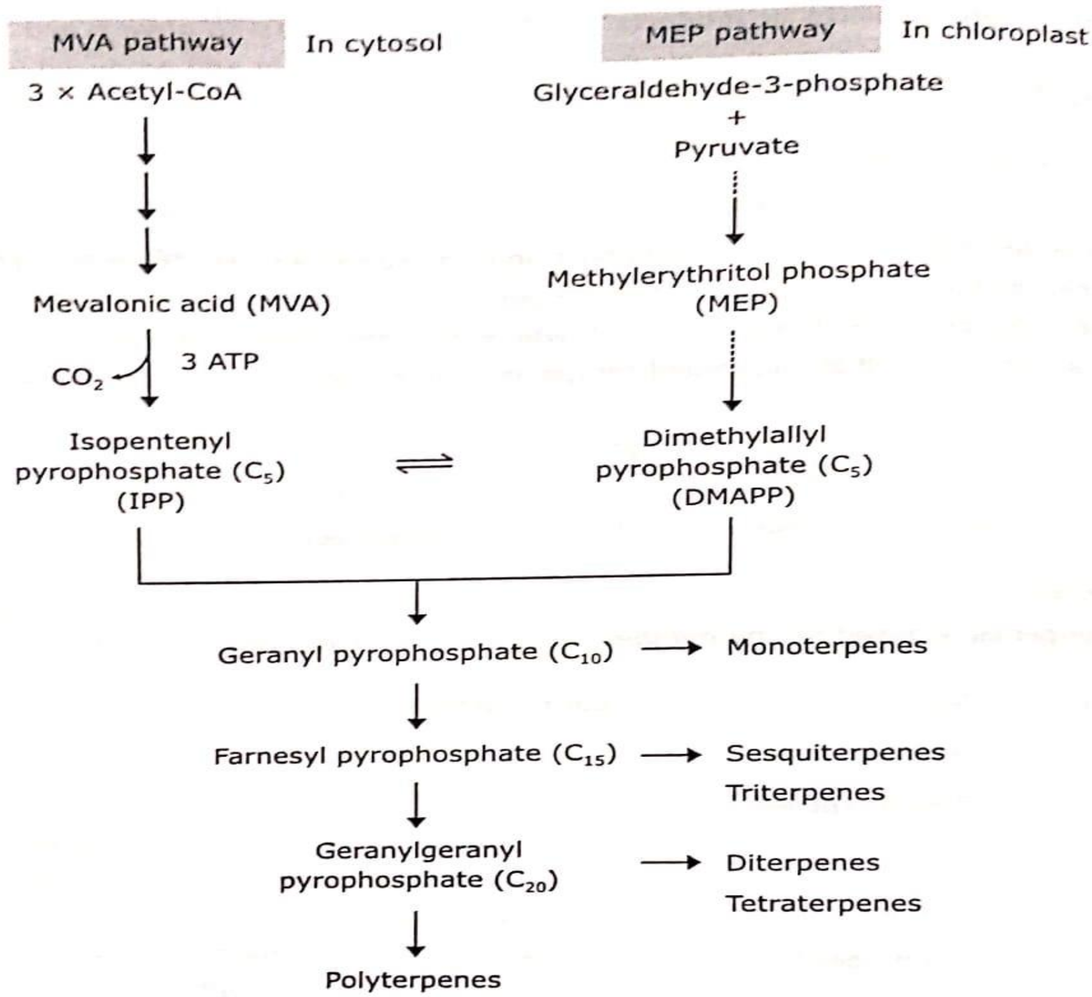


Fig – <u>Out line of terpenes biosynthetic pathway</u>

Classes of terpenes with their ecological significance :-

Terpene	Example	Ecological significance
Monoterpenes	Menthol Limonene, Camphor Pyrethroids	Flavouring Medicinal Insecticidal activity
Sesquiterpens	Abscisic acid Gossypol Pentalenolactone Farnesol	Phytohormone Anticancer Antibiotic Perfumery raw material
Diterpenes	Gibbrellins Taxol Casbane Dihydroleucodine	Phytohormone Anticancer drug Phytoalexin Antioxident
Triterpenes	Cardenoilds	Therapeautic use
Tetraterpene	B-carotene	Plant pigment
polyterpene	Plastoquinone Rubber	Electron transfer Indusrial raw material

6.7.2.Phenolics:-

Plant produce a large variety of secondary compouds that contain a phenol group a hydroxyl group a hydroxyl functional group a hydroxyl functional group on an aromatic ring .Thease substance are classified as phenolics compounds , or phenolics.

Some are soluble only in organic solvents , some are water soluble only in organic solvents, some are water souluble carboxylic acid and glycosides and other are large , insoluble polymers.

Function of phenolics –

1.phenolics serve as attract the pollinators and fruit disperse .
2.Reducing the growth of near by competing plants .
3.Absorbing harmful ultraviolet radiation .
4.Also defense against hervivores and pathogen

Biosynthesis Pathway of phenolics

Phenolics $\longrightarrow$ Shikimic acid pathway and malonic acid pathway

Erythrose-4-phosphate
+
Phophoenol pyruvate

$\downarrow$ Shikimic acid pathway

phenylealanine

PAL Enzyme $\downarrow$ Deamination

Trans cinamic acid

$\downarrow$

Simple phenolics

Classes of phenolics

. Coumarins
. Lignin
. Flavonoids
.Tanins

6.7.3Alakaloids

Alkaloids are aromatic nitrogenous compounds.These are organic substance that are produced by plant which act as protective substance against animal insect attacks.

Example-

Narocotic alkaloid used in medicine include morphine and codeine for the relief of pain cocaine as a local anesthetic.

Plant species producing Alkaloids

Alkaloids	Plant species
Atropine	Atropa belldona
Quinine	cup
Caffeine	Tea (leaf)
colchicine	Colchicum byzanthium
srychnine	Strychnos nuxvomica
Nicotine	Tabaccum (leaf)
Cocaines	Erythroxylon coca (leaf)

6.7.4.Glycosides

It is a molecule in which carbohydrate (sugar) is bound by a glycosidic bonds to non carbohydrate moiety containing hydroxyl group .

Non Carbohydrate part may be terpenoid , steroids, flavonoids ,

and other phenolics.

Different types of glycosides-

1.Saponins
2.cyanogenic glycosides
3.caradiael glycosides

Previous Year Question

JUNE - 2014

1. In terpene biosynthesis pathways, three acetyl-coA are joined together step wise to form mevalonic acid .which one of the following three steps is required by mevalonic acid to form isopentenyl diphosphate or Isopentanyl Pyrophophate(IPP)?

(A) Pyrophosphorylation, decarboxylation,and dehydration
(B) Alkylation,pyrophosphorylation and decarboxylation
(C) Methylation,dehydration and alkyalation
(D) Phosphorylation,carboxylation and methylation

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	A	6.7.1

DECEMBAR-2014

1.Following are certain statements regarding secondary metabolites found in plants.

i) All terpenes are derived from a 6-carbon element

ii) Alkaloids are nitrogen containing compounds.

iii) Pyrethroids ,a monoterpene ester found in the leaves and flower of chyrysanthemum species, show insecticidal activity.

iv)Limonoids are groups of alkaloids and have antihervivoral activity.

Which one of the following combinations of above statements is/are correct?

a)1and 2 b)1 and 4

c)2 and 3 d)3and 4

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	C	6.7.1

DECEMBAR-2015

1. Following are certain statements regarding terpene class of secondary metabolites in plants:

A. Isopentenyl diphosphate and its isomer combine to form larger terpenes.

B. Diterpenes are 20 carbon compounds.

C. All terpenes are derived from the union of 4-carbon elements.

D. Pyrethroids are monoterpene esters.

Which one of the following combination of above statements is correct?

1. A, B and C
2. A, B and D
3. B, C and D
4. A, C and D

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	2	6.7.1

DECEMBAR-2016

1.Which one of the following compounds is **NOT** a part of alkaloid class of secondary metabolites?

1. Lignin
2. Indole
3. Tropane
4. Pyrrolidine

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	1	6.7

JUNE-2017

1.The following statements are made regarding secondary metabolites in plants.

a)All secondary metabolites are constitutively produced in all cells of plant during its entire life .

b)They serve as signals to help the plant to survive in adverse conditions.

c)They may be volatile compounds

d)They contribute to flower colour.

Which one of the following option represents a combination of correct statements?

1.a,b and c	2.b,c and d
3.a,c and d	4.a,b and d

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	2	6.7.1

Sub Unit– 8

STRESS PHYSIOLOGY

6.8 Any change in the surrounding environment many disrupt homeostasis. Environment modulation of homeostatic may be defined as biological stress. Plant stress is a adverse effect on the plant which induced upon a sudden transition from some optimal enviromental condition and if disrupts this intial homeostatic state.

Stress in plant can be defined as any external factors that negatively influences plant growth , productivity ,reproductive capacity or survival.

Plant stress divide into two broad catagorised according to different factors these are-

3. Abiotic Stress
4. Biotic stress

1.Abiotic Stress:-

Abiotic stress is negative impact of nonliving factor on the plans in a specific environment.

Example:- light, temperature, water, salt, gravity etc.

2.Biotic Stress:-

Biotic stress is a biological harm (e.g:- insect, pathogen) to which a plant may be exposed during its life time .

Example:- insect, pathogen,etc

6.8.1Temperature Stress effect:-

Heat stress causes divers and often adverse alteration in plant growth, development, physiological processes, and yield. One of the major consequences of H+ stress is the excess formation of reactive oxygen species (Ros) which leads to oxidative stress.

Plant Responses:-

Heat stress affects all the major plant process like germination, growth, development, reproduction, and ultimately yield. Seed germination is severely affected by high temperature. It reduce germination percentage. High temperature also causes loss of cell water content ultimately reducing growth.

High temperature has a greater influence on the photosynthetic capacity of plant especially of C3 plants than C4 plants.

Reproductive tissues are most sensitive to high temperature . High temperature often causes excessive ethylene production leading to male sterility of rice pollens.

<u>Prevention (acclimation to high temperature)</u>

In case of sudden heat stress, the import short term responses are:-

2. Leaf orientation
3. Transpirational cooling
4. Change in membrane lipid composition.
5. Waxy cuticle layer of leaf reduce heat stress.
6. Large xylem vessel.

Tolerance to high temperature

Antioxidant metabolites like SOD, GSH, tocopherol and carotene also protect plants against oxidative stress. Plant produce antioxidants enzyme like peroxidase, catalase super oxide dismutase.

In higher temperature organism express heat shock proteins.

Low temperature affect plant:-

Chilling resistant plants tend to have membranes with more unsaturated fatty acid that increase their fluidity, Whereas chilling sensitive plants have a high percentage of saturated fatty acid chains that end to solidity of low temperature.

<u>6.8.2Salt Stress</u>

High salinity affects plants in several ways, water stress, ion toxicity, nutritional disorders, oxidative stress, reduction of cell division, plant growth developments and survival.

All major process such as photosynthesis, protein synthesis and lipid metabolism are affected.

<u>Effect on plant</u>

High salinity affects plants in two main ways - -

1. High salinity in the soils disturbs the capacity of roots to absorb water.
2. High concentration of salts inhibition many physiological and biochemical process such as nutrient uptake and assimilation.

Mechanism of tolerance

Plants are evolved many mechanism to acclimatize to salinity. These one-

1. The tolerance of osmotic stress,
2. The Na+ exclusion from leaf blades.
3. Tissue tolerance.

6.8.3Water Stress:-

Plants are required some physical factors, like light, temperature, air, water etc. and some chemical factors like nutrients, organic molecules etc.

Water stress show in plants for two condition of water availability are termed as follows:-

2. **Drought:-**

   It refers to a situation where any area receives annual rainfall less then average rainfall it receives generally .Drought to a situation where transpiration rate exceeds absorbtion rate so plant experience a stress. Water logging (Excess of water) cause blockage of oxygen for plants and their roots. Plant shift from aerobic to nonaerobic condition.

Effect of water stress on plants (Drought)

- Decrease of growth rate of stem elongation, of leaf expansion and of stomal aperture.
- Drought stress condition acidity the chloroplast stroma causing inhibition to the Rubisco activity.
- In plant cell water potential become reduce due to drought condition.
- In this stress condition, Over production of reactive oxygen species (Ros)

Prevention :-

- The plant hormone ABA accumles under water deficit conditions and play a major role in response and tolerance to dehydration.
- During mild or short term water shortage, photosynthesis is strongly inhibited, but phloem translocation is un affected until the shortage become severe.

Previous Year Question

DECEMBAR-2014

1. Following are some statements related to osmotic stress in plants.

   1. The accumulation of ions during osmotic adjustment is predominantly restricted to the vacuoles

   2. In order to maintain the water potential equilibrium within the cell ,other solutes called as compatible solutes or compatible osmolytes accumulates in cytoplasm.

   3. Galactose is one of the compatible osmolytes involved osmotic stress in plant .

   4. There are mainly four groups of molecules that frequently serve as a compatible solutes .

   Which one of the following combinations of above statement is /are correct?

   a) 1,2and3

   b) 2,3 and 4

   c) 1,2 and4

   d)1,3 and 4

Answer with Reference

SL. NO.	QUESTION SL. NO.	ANSWER	REFERENCES
1.	1	C	6.8