College of Science Al-Mustanseryea University

Biology

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Subject: Plant Physiology

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Lecture: 3

Plant Hormones

Plant hormones: are a group of naturally occurring, organic substances which effect physiological processes at low concentration.

Characters of plant hormones:

1- organic substances.

2-affects plant growth and development.

3-opreats in a very low concentration.

*****Hormones may classified into these classes:**

A/Promote hormones:

1-Auxins 2-Gibbrelline 3-Cytokinins

B/Inhibit hormones:

1-Ethylen 2-Abscisic acid

*****There are some definitions in plant hormones:**

1-plant regulators: are organic compounds other than nutrients that in small amounts promote, inhibit or modify a physiological process in plants.

2-plant hormones: are regulators produced by plants which in low concentration regulate plant physiological processes. Hormones usually move within the plant from site of production to a site of action.

3-growth regulators: are regulators that affect growth.

4-flowring regulators: are regulators that affect flowering.

******Auxins(Indol acetic acid – IAA)******

1-Firist plant hormones to be discovered.

2-very simple chemical structure, dramatic influences on growth.

3-early on it was believed to be the master (plant hormone)

4-growth promoting hormone.

5-Auxin found in embryo of seed, young leaves, meristem of apical buds.

****there are some physiological effects influenced by Auxins:**

1-cell enlargement of stems, leaves and roots.

2-cell and organ differentiation.

3-flower initiation and development, fruit set, fruit growth, and embryo growth.

4-abscission of leaves, flowers and fruits.

5-direction of growth (tropism of stems or roots).

6-apical dominance.

7-parthenocarpy in some plants.

8-enlargment and cell division of callus tissue culture.

****Tropism:** it is defined as the movement of plant organ towards the environmental stimulus such as light, gravity, water and chemical stimulus. There are several types of tropism:

1-photo tropism: it is bending of plant towards the light source due to translocation of auxin to the shaded side. The increased concentration in the shaded side causes increase in cell enlargment and growth of the cell in this region and cause bending.

2-Eotropism: movement of roots towards the earth center due to earth gravity. This happens due to accumulation of auxin in the lower region. Roots are different from stems in their response to auxin. High concentration of auxin in roots causes inhibition instead of stimulation. Root is positive geotropism while stem is negative geotropism.

3-Apical dominance: it is phenomenon in which apical bud dominate over the lateral bud and doesn’t allow it to grow. This happens when the auxin in the apical bud translocated to lateral buds and increases their auxin concentration. The high concentration of auxin inhibited growth of lateral buds.

Scientists found the presence of several compound of indol in nature which have similar function of IAA such as Indole pyruvic acid, Indol acetonitrl and Indol acetaldehyde.

These compounds may be metabolized and change to IAA in plants.

There are two kinds of auxin in plants:

1- Free auxin, which can be isolated by diffusion.
2- Bound auxin, which cannot be isolated by diffusion.

There are some compound similar to auxin and these compounds have the ability to bind with auxin and inactivated it, these are called **antiauxins**.

*****Gibberellins (GA)******

Gibberellins are belonged to terpenoids group which synthesized from isoprene units.

*****positions of GA synthesis in the plants:**

1- leaves. **2**-roots. **3-**buds. **4-**embryo and fruits.

GA are broken down slowly in plant. Also it can be transformed into inactive form by conjugation with sugar or protein molecules.

*****GA movement in plants:**

GA moved through phloem and xylem.

****GA present in plant in two forms:**

1- Free GA which are the active form.
2- Bound GA in this case, GA bound to sugar by glycoside linkage or proteins. It was believed that the bound form is sort of storage process used by plant.

Anti Gibberellins:

It is also called growth retardant compounds:

1- cycocel. 2-phosphon. 3-cultar.

All these compounds caused dwarf of the plants and increased plant tillering.

***Mechanisms of action of GA:**

1-Activation of cell division in shoot apex.

2-stimulate cell elongation.

3-increase the plasticity of cell wall and thus enlarge the cells of stem.

4-activation of genes responsible for the synthesis of hydrolytic enzyme in the endosperm during seed germination.

physiological effect of GA:

1- Control genetic dwarfism: genetic dwarfism is caused by gene mutation in some crop cultivars such as corn, peas.
2- Stimulation of flowering and growth of flower branches:
A/ in some plants growth of leaves become very dense and the branch of flower are stunted (rosette). This happens in long day plants which doesn't receive enough light.

B/ in other plants the flowering branch is elongated abnormally because the plant doesn’t received enough cold temperature.

3- Inhibition of root formation in cutting and callus:

GA stimulates translocation of nutrients from the region of roots formation in the cutting and callus to other parts causing inhibition.

4- Stimulate germination of seed which required dark conditions:

Some seeds require dark conditions to germinate. Treatment of seeds with GA causes germination in light condition.

5- GA stimulates male flower in some plants such as cucumber. Other GA stimulate female flower.

6- Stimulate the synthesis of enzymes in endosperm of germinated seeds such as α- amylase, β-amylase, proteases, ribonucleases.

7- Breaking the dormancy of seeds and buds:

Dormancy means inability of seeds to germinate and buds to grow in presence of favorable environment (moisture, temperature and light).

When the seeds or buds treated with cold temperature (4°C) for a definite period, both of them germinate. It was found that GA can substitute cold temperature and caused germination of seeds and growth of buds.

Lec:4

Photosynthesis

Photosynthesis is considered the most important process for all living organisms (except for anaerobic bacteria which can fix CO_2 without using hydrogen of H_2O as a source of proton). Photosynthesis is simply a light-driven series of chemical reactions that convert the energy-poor compound, CO_2, to energy-rich sugars. In plants, photosynthesis also splits water and release Oxygen(O_2). The photosynthesis organisms produce about 50 million ton of sugar annually by this process. Photosynthesis needs the following essential requirements:

1-Source of light energy

2-Source of energy capture

3-Means for energy storage

In plants photosynthesis can be summarized into the following general equation:

$$CO_2 + H_2O \xrightarrow{light} Sugars + O_2$$

Chlorophyll

Light energy: To understand photosynthesis , we must know a little about the properties of light.

In 1905, Einstein proposed that light consist of packets of energy called **photons**, which are the smallest divisible units of light. The intensity (i.e. brightness) of light depends on the number of photons. Light intensity is important in photosynthesis because each photon carries a fixed amount of energy that is determined by the photons wavelength. Wavelengths of visible light are measured in nanometers. The longer the wavelength, the less energy per photon. Sunlight consist of a spectrum of colors of light having different wavelengths and energy.

Light energy is defined as waves of fine particles called photons or quantum. Atom of any element requires one quantum for excitation and one molecule of any element requires 6.02×10^{23} (Avogadro number) of quantum for excitation.

Photosynthetic pigments: Studied conducted by plant physiologists indicated that the pigments absorbed light energy and transfer it to chemical energy are the chlorophylls which occurred in the plastids. The pigments are classified as follow:

1/Chlorophylls: the quantity of chlorophyll is 10 times more than carotenoids and it includes the following types:

a/ chlorophyll a : occurred in all photosynthetic plants and maximum absorption of light appeared at 430 and 660 nm wave lengths.

b/ chlorophyll b : occurred in all higher plants and green algae and maximum absorption of light appeared at 453 and 645 nm wave lengths.

c/ chlorophyll c : occurred in brown algae.

d/ chlorophyll d : occurred in red algae.

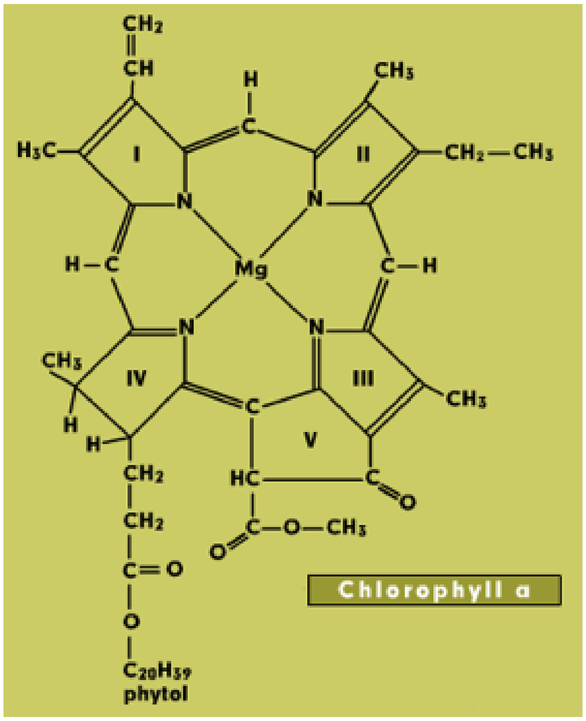
e/ chlorophyll e : occurred in some plant species.

****Differences between chlorophyll a and b :**

Chlorophyll a	**Chlorophyll b**
$C_{55}H_{72}O_5N_4Mg$	$C_{55}H_{70}O_6N_4Mg$
Molecular weight 892.32 gm	Molecular weight 906.32 gm
Carbon no.3 attach to methane(CH_3	Carbon no.3 attach to aldehyde(CHO)
Best solvent is Ether	Best solvent is methyl alcohol
Maximum absorption at 120 and 70	Maximum absorption at 160 a 50 nm

Chlorophyll structure:

The chlorophyll structure is roughly resembled a "tennis racket" having a large head called **porphyrin** and a long handle or tail called **phytol**. The phytol (the tail) is a long chain alcohol containing one double bond and esterifies with carboxyl group on C_7 atom of the chlorophyll molecule.



**other pigments:

1-Carotenoids: they are lipid compounds that are distributed widely in both animals and plants and range in color from yellow to purple.

2-Xanthophylls: they are more abundant in nature than carotenes and located in chloroplast. They are carotenes containing oxygen.

The function of carotenoids :

a/protect chlorophylls against photo oxidation in excessive light.

b/absorption of light and transfer it to chlorophylls.

c/causes phototropism in plants.

*****photophosphorylation:**

The process by which the plant can produce ATP in the presence of light and it happens in the plastids and through the light reactions. There are two types of photophosphorylation:

1/ Non-cyclic photophosphorylation:

2/Cyclic photophosphorylation:

****Function of light reactions:**

1-production of O_2 which is necessary for life continues.

2-formation of $NADPH_2$ which is necessary for metabolic reactions including dark reaction.

3-formation of ATP which is very necessary for metabolic reactions including dark reaction.

*****Dark reactions:**

The famous plant biochemist Dr. Calvin from university of California used the above technique and found that phosphoglyceric acid (PGA) was the first compound produced from the fixation of CO_2 in to 5 carbon compound named Ribulose diphosphate according to the following reaction:

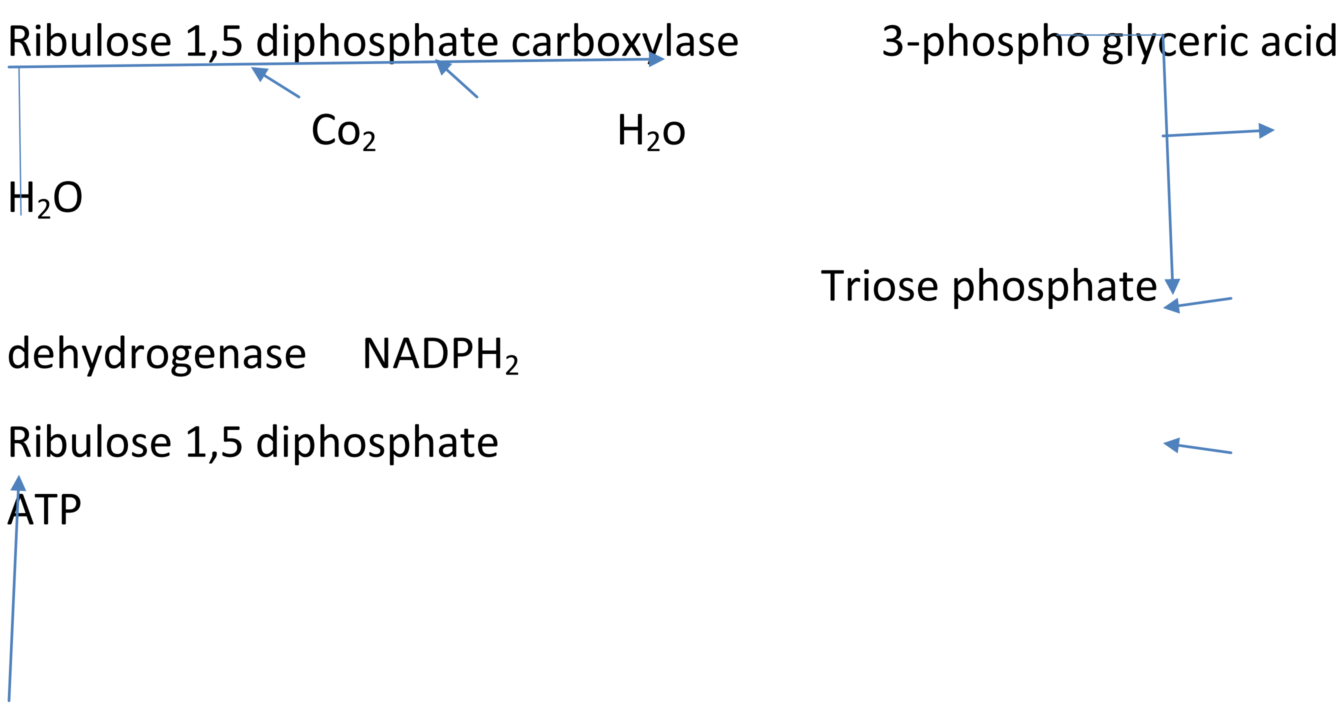
Ribulose diphosphate + CO_2 → 2Phosphoglyceric acid(PGA)

The enzyme catalyzed this reaction is **Ribulose diphosphate carboxylase** which is proved to be biosynthesized in chloroplast. It has been shown that one mole of CO_2 requires 3 moles of ATP and 2 moles of $NADPH_2$. The dark reactions which known to be a cyclic have collectively named **Calvin cycle**.

Methods of CO_2 fixation: studies revealed the presence of 3 kinds of CO_2 fixation in plants. Accordingly, the plants were divided into 3 groups:

1* C_3 plants:

The plants with 3C compound as a primary initial CO_2 fixation product such as wheat, tomato and date palm. The compound is **PGA**.



Phosphor pento kinase 3-phospho glycer

aldehyde

← ATP

Ribulose-5- phosphate ← Trans ketolase

Calvin- Benson cycle (C_3 **Plants)**

2*C_4 Plants:

The plants with 4C compound as a primary initial CO_2 fixation product such as corn and sugar cane. The compound is **oxaloacetate**.

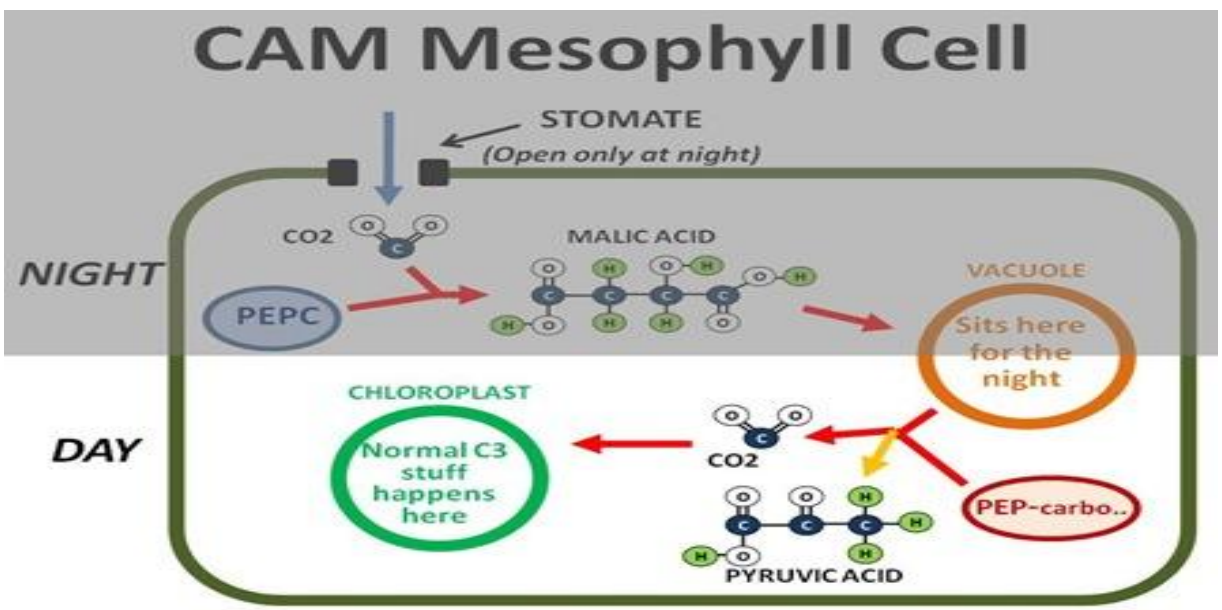
CO_2 gas is fixed first in the phosphor phenol pyruvate (PEP) which is present in the chloroplasts of the mesophyll cells forming a 4C compound named oxaloacetate. The oxaloacetate converts into malate which moves to enter the chloroplast of the sheath cells, then converts to pyruvate and CO_2. The CO_2 is re-fixed again in Calvin cycle while the pyruvate enters the chloroplast of the mesophyll cells to convert into PEP.

3*CAM plants:

Means plants with crassulacean acid metabolism. They called CAM since it was first investigated in plants of Crassulacean family which are commonly produced crassulacean acid. Plants of this group open their stomata at night to fix CO_2.

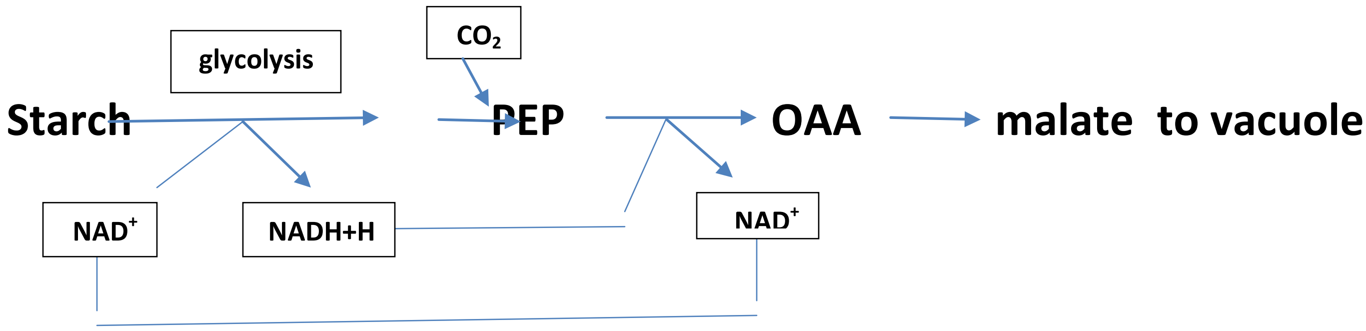
During night, starch breaks down by reaction of glycolysis to form phosphor phenol pyruvate (PEP) . CO_2 is fixed into oxaloacetate by the enzyme PEP carboxylase, then this acid is converted to malate by dehydrogenase enzyme. Malate is stored in the vacuole.

During day-light, malate come out of the vacuole and dehydrogenated to form oxaloacetate again. Oxaloacetate is decarboxylated to form CO_2 and PEP . the CO_2 is re-fixed into Calvin cycle while PEP convert to starch by reverse glycolysis. Some of starch produced by reverse glycolysis and Calvin cycle can be utilized again during night to fix CO_2 again.



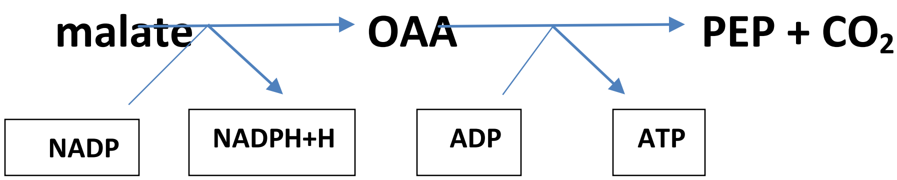
CO_2 fixation in CAM plants:

1-Darkness (stomata opened):

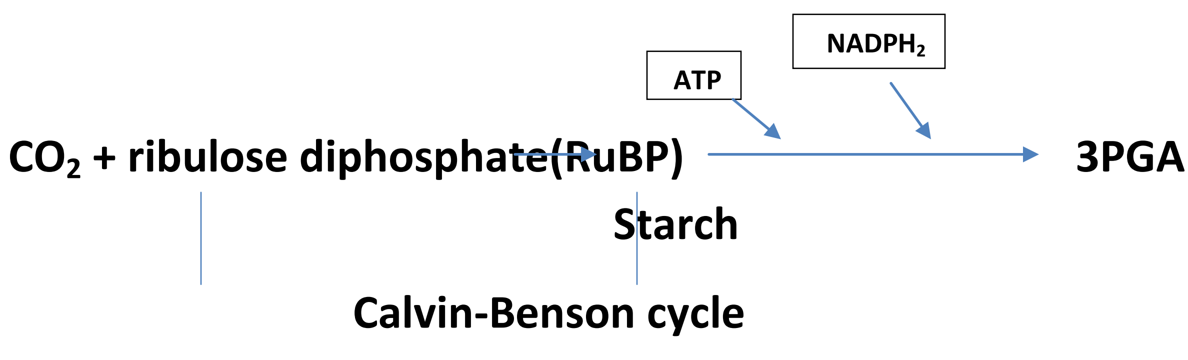


2-Day-light (stomata closed):

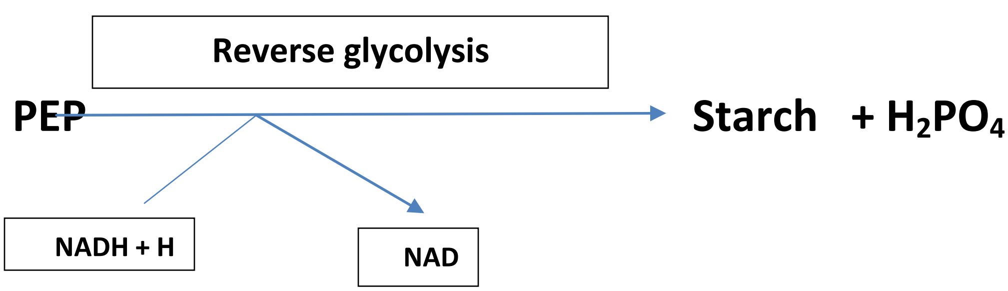
a/



b/

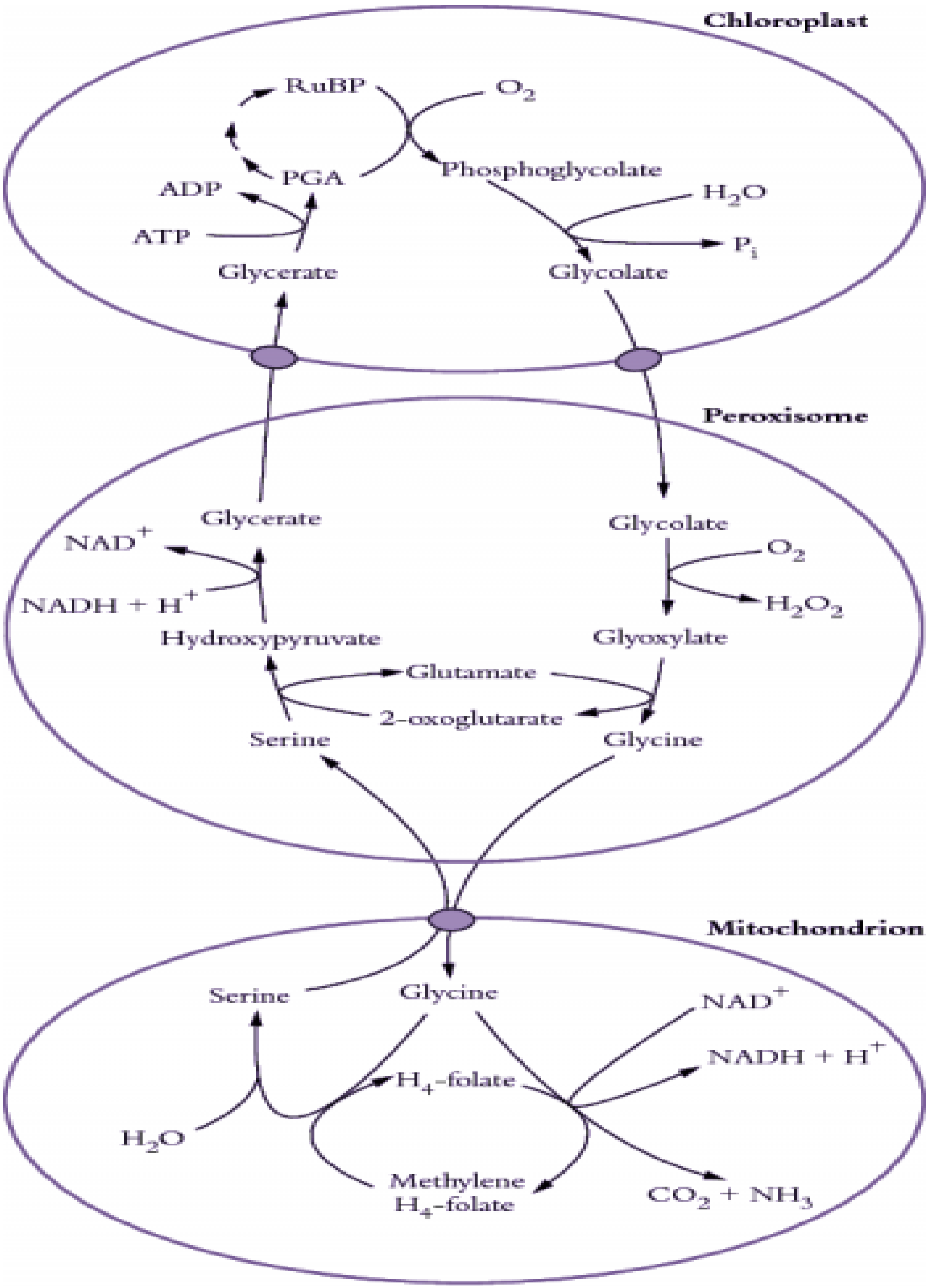


c/



***Photorespiration:

Photorespiration presents in all plants and takes place in the presence of light. The reactions of photorespiration are completed in 3 cellular structures namely **chloroplast**, **perexisome** and **mitochondria**. The first reaction starts with the combination of O_2 with the Ribulose diphosphate carboxylase to form glycolate and 3-phosphoglyceric acid (3-PGA). Both compounds moved from the chloroplast to the peroxisome. The glycolate converts to glyoxylate which converts to glycine. 3-phosphoglyceric acid convert to glyceric acid which converts to hydroxyl pyruvate then to serine. Serine moves to mitochondria to convert to glycine by decarboxylation process. The process is important for biosynthesis of the amino acids (glycine and serine) which are essential for protein biosynthesis.



Metabolic path ways of photorespiration

Factors affecting rate of photosynthesis:

1-CO_2 concentration: both concentration and diffusion affect photosynthesis rate. It has been shown that the diffusion of CO_2 inside the internal leave tissues is controlled by diameter aperture. The diffusion of CO_2 increased with the increasing diameter of the aperture. Photosynthesis is increased with the increased CO_2 concentration up to a define limit after the concentration becomes toxic to plants. the upper limit varied with plant species.

2-O_2 concentration: the increased in O_2 con. significantly decreased the rate of photosynthesis. It has been suggested that the high concentration of O_2 competes with CO_2 on the hydrogen ions of $NADPH_2$ and combines with them to form H_2O. In this case CO_2 fixation is inhibited (means photosynthesis is inhibited).

3-Water: water is very important factor that affects the rate of photosynthesis under drought conditions, stomata close and diffusion of CO_2 and O_2 inside the leave inhibited and these lead to inhibit the rate of photosynthesis. Excess water also inhibit the rate of photosynthesis. Flooding of plants prevents CO_2 and O_2 and thereby reducing photosynthesis rate.

4-Temperature: extreme temperature is significantly inhibited photosynthesis rate. The low temperature freezes the water inside and outside the cells and thus preventing the movement of CO_2 and O_2 into the cells. It also causes protein denaturation. The high temperature inhibits or destroys enzymes including enzymes of Calvin cycle. Generally the increase temperature increases the activity of the plant to a limit then the increase in temperature harms the plant.

5-Light intensity: It has been shown that rate of photosynthesis increases with increasing light intensity to a limit after which, the increase in light intensity slightly increases the rate of photosynthesis. however at very light intensity, the rate of photosynthesis inhibited due to photooxidation of chlorophylls.