# Plant physiology

For 4year students, general education

(Biological and Geological Sciences Division)

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# رؤية الكلية

تسعى الكلية الى مساعدة الجامعة فى تحقيق اهدافها الاستراتيجية من خلال ان تكون واحدة من الكليات المتميزة والمنافسة داخليا وخارجيا فى التعليم وخدمة المجتمع والبحث العلمى من خلال تحقيق مستوى رفيع من الاداء وتقديم خريج متميز يقابل الاحتياجات المتعددة بسوق العمل الداخلى والاقليمى والخارجى

# رسالة الكلية

**تهدف كلية التربية بالغردقة الى التميز من خلال:**

- **إعداد المربين والمعلمين المتخصصين والقادة إعداداً أكاديمياً ومهناً وثقافياً فى مختلف التخصصات التربوية.**
- **تنمية القدرات المهنية والعلمية للعاملين فى ميدان التربية والتعليم بتعريفهم بالاتجاهات التربوية الحديثة.**
- **إجراء البحوث والدراسات فى التخصصات التربوية والمختلفة بالكلية.**
- **نشر الفكر التربوى الحديث واسهاماتة لحل مشكلات البيئة والمجتمع.**
- **تبادل الخبرات والمعلومات مع الهيئات والمؤسسات التعليمية والثقافية المختلفة.**
- **تنمية جوانب شخصية الطلاب ورعاية الموهوبين والمبعدين.**

# Contents

# A- Plant Metabolism

- Plant metabolism is defined as the complex of physical and chemical events of photosynthesis, respiration, and the synthesis and degradation of organic compounds.
- Metabolism in plants is the collection of interrelated biochemical reactions that maintain plant life. A series of metabolic processes happen in different parts of the plants such as leaves, stems, and roots. These processes include photosynthesis, respiration, and nitrogen fixation.

Plant Metabolism

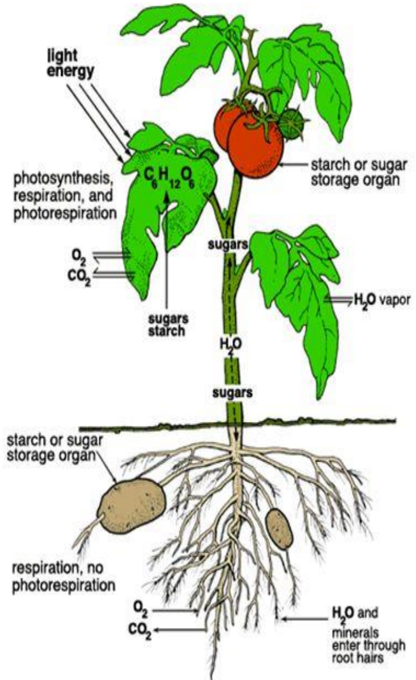
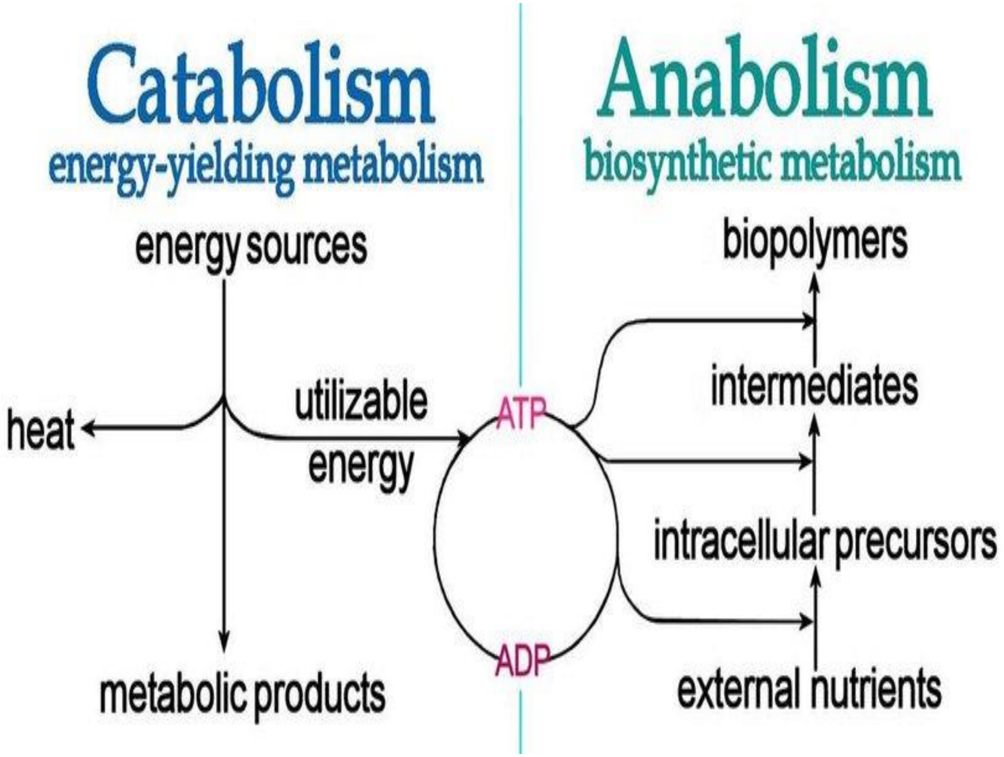



**Figure 24.** Photosynthesis, respiration, leaf water exchange, and translocation of sugar (photosynthate) in a plant.

# A- Plant Metabolism

- **Anabolism** is the total series of chemical reactions involved in synthesis of organic compounds.

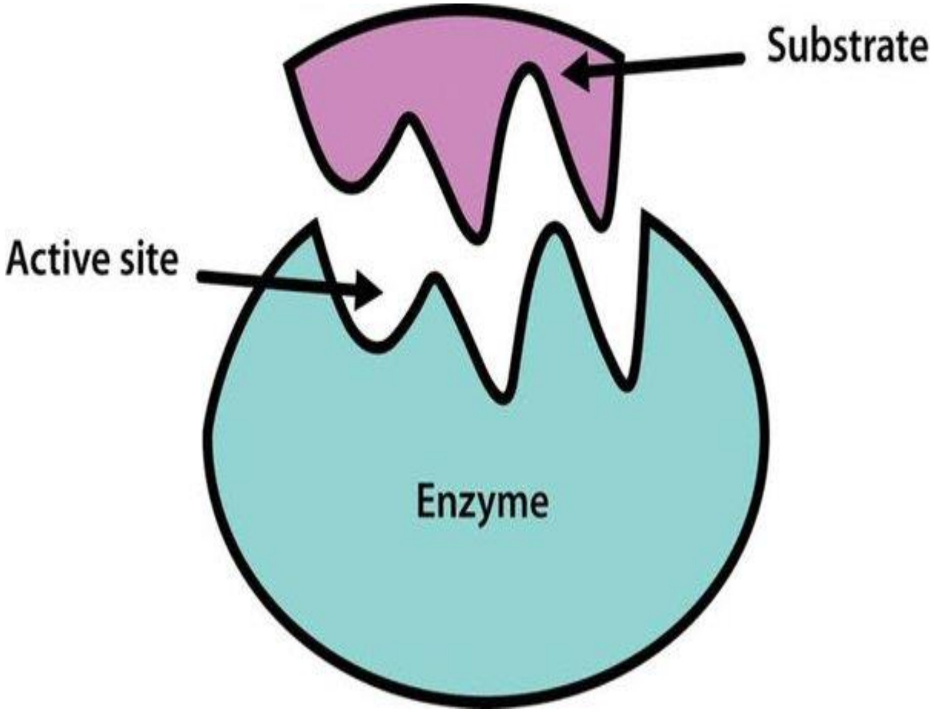
- **Catabolism** is the series of chemical reactions that breakdown larger molecules. Energy is released this way, some of it can be utilized for anabolism.



# Difference Between Catabolism and Anabolism

| Catabolism | Anabolism |
|---|---|
| Catabolism breaks down big complex molecules into smaller, easier to absorb molecules. | Anabolism builds molecules required for the body's functionality. |
| The process of catabolism releases energy. | Anabolic processes require energy. |
| Examples of catabolic processes are proteins becoming amino acids, glycogen breaking down into glucose and triglycerides breaking up into fatty acids. | Examples include the formation of polypeptides from amino acids, glucose forming glycogen and fatty acids forming triglycerides. |
| In catabolism, potential energy is changed into kinetic energy. | In anabolism, kinetic energy is converted into potential energy. |
| It is required to perform different activities in living entities. | It is required for maintenance, growth, and storage. |

# 1. Enzymes

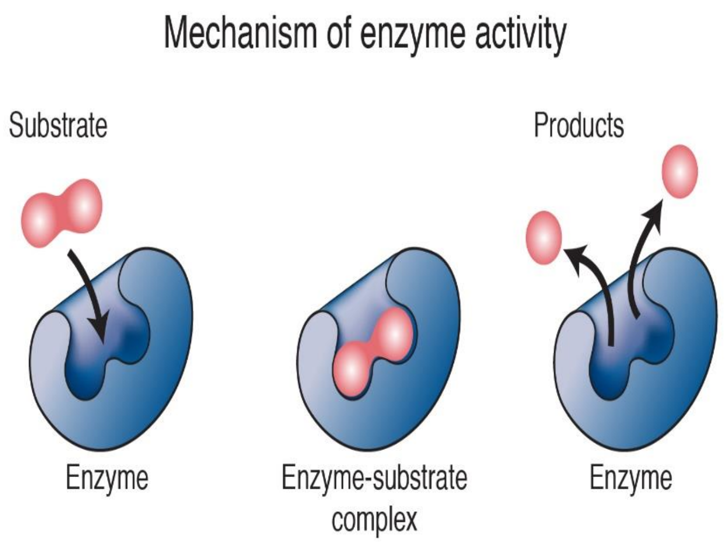


# 1. Enzymes

- Enzymes are biological catalysts that increase the rate of chemical reaction by lowering the activation energy and without change or being consumed in the reaction.

- The molecules involved in the enzyme mediated reactions are known as **substrates** and the outcome of the reaction is known as **product**.

- Generally, the chemical nature of most enzymes are **proteins**.



# 1. Enzymes

- Enzymes are a linear chain of amino acids, which give rise to a three-dimensional structure.
- The sequence of amino acids specifies the structure, which in turn identifies the catalytic activity of the enzyme. Upon heating, the enzyme's structure denatures, resulting in a loss of enzyme activity, which typically is associated with temperature.
- Compared to its substrates, enzymes are typically large with varying sizes, ranging from 62 amino acid residues to an average of 2500 residues found in fatty acid synthase. Only a small section of the structure is involved in catalysis and is situated next to the binding sites.
- The catalytic site and binding site together constitute the enzyme's active site. A small number of ribozymes exist which serve as an RNA-based biological catalyst. It reacts in complex with proteins.

# Chemical Nature Of Enzymes

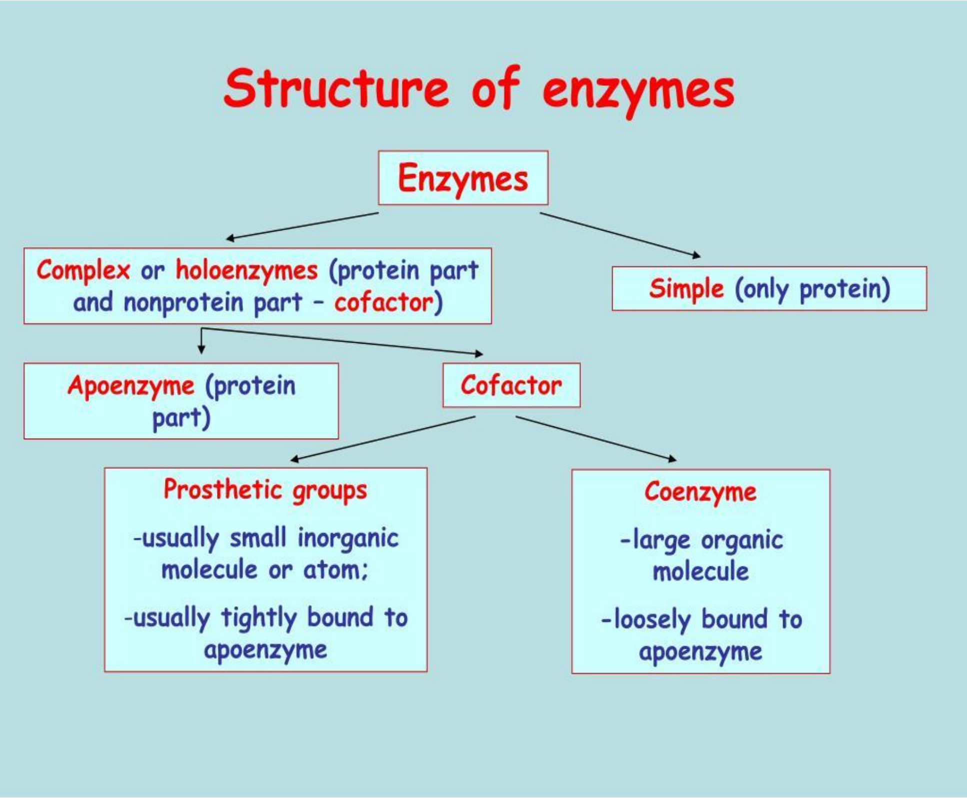
According to the chemical nature of enzymes, enzymes are classified into **2 types**:

1. Simple Protein enzymes: They are formed of protein only.

2. Complex (conjugated) Protein : enzymes formed of two parts:

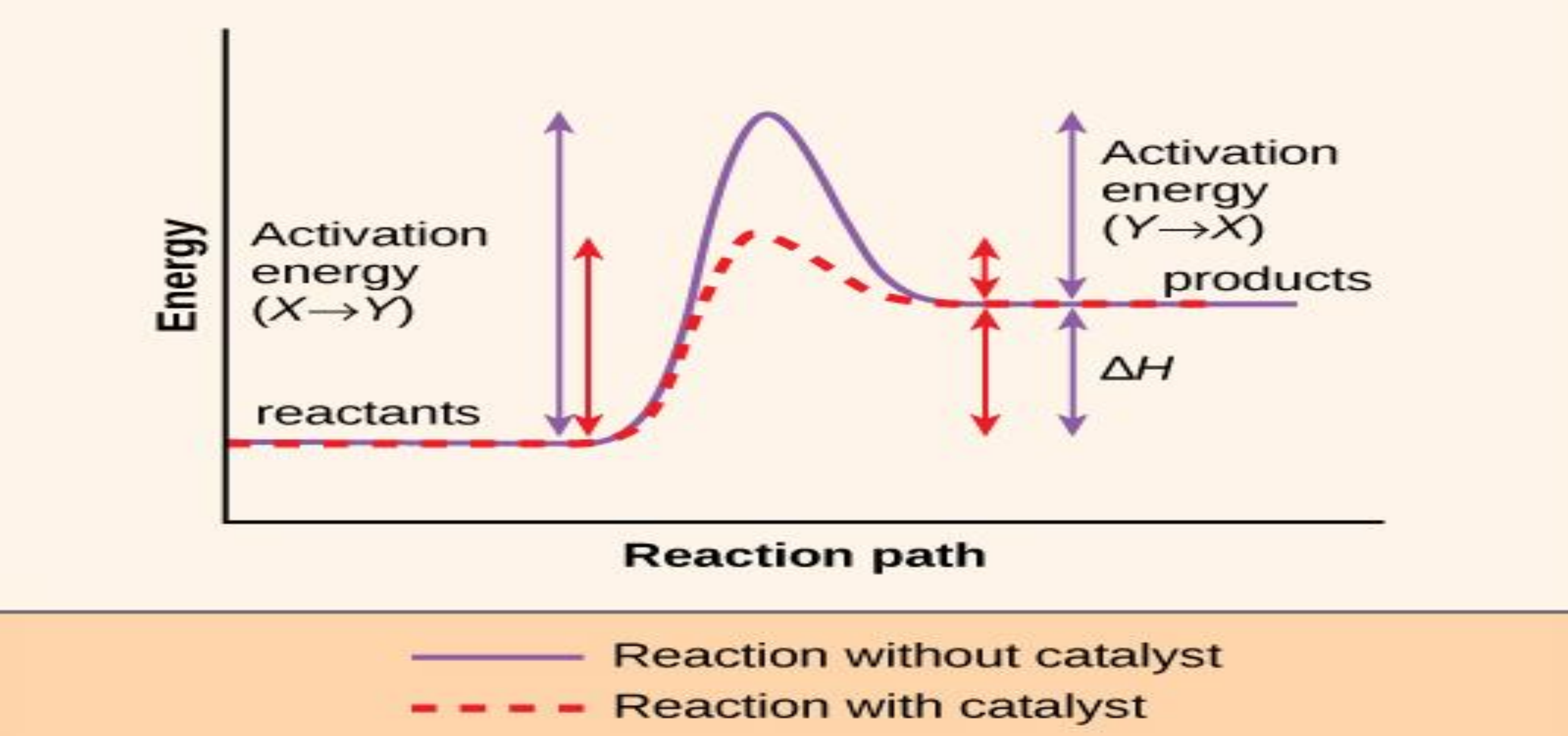
1) Protein part: called **APOENZYME**

2) Non- protein: called **COFACTOR**.



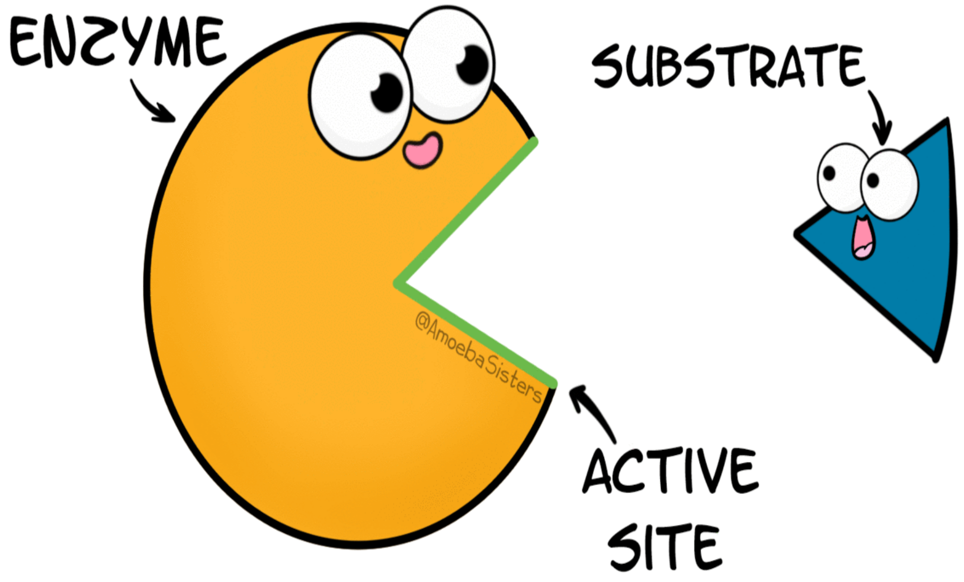

- The whole enzyme is called holoenzyme

# Enzyme Lower Activation Energy Of A Reaction



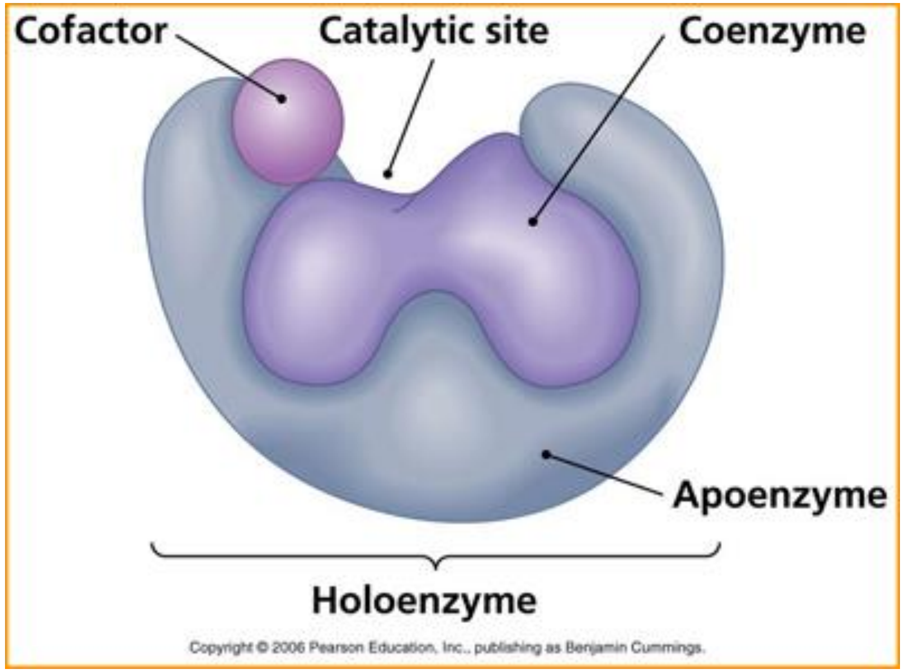
# Characteristics Of Enzymes

- It speeds up the chemical reactions
- Enzymes have a specific shape
- Enzymes are required in minute amounts
- Enzymes are particular in their actions.
- Enzymes are affected by temperature.
- Enzymes are affected by pH.
- Inhibitors inhibit enzymes
- Some enzymes require coenzymes
- Some enzymes catalyze reversible reactions



# CO-FACTOR

- A cofactor is a non-protein chemical compound or metallic ion that is required for an enzyme's role as a catalyst (a catalyst is a substance that increases the rate of a chemical reaction). Cofactors can be considered "helper molecules" that assist in biochemical transformations.
- Examples: Vitamins, minerals, and ATP are all examples of cofactors. ATP functions as a cofactor by transferring energy to chemical reactions.

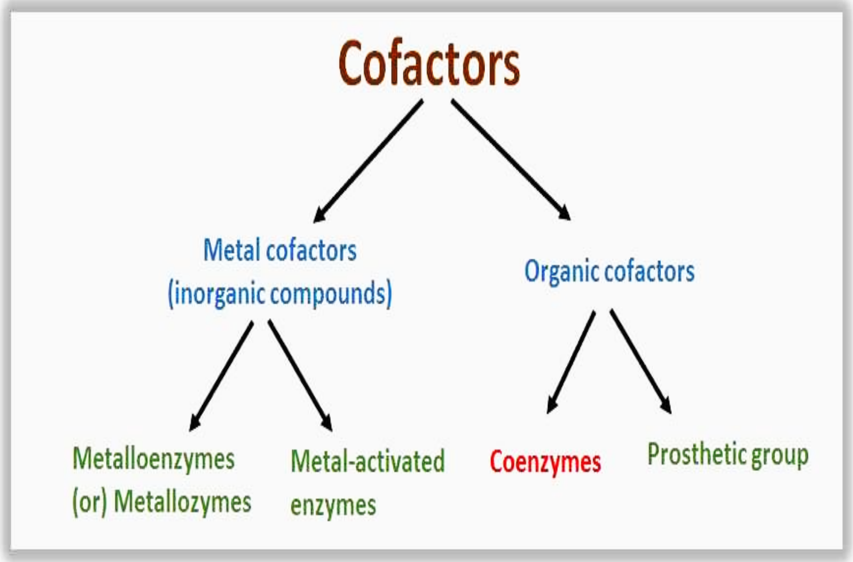


# Types Of CO-FACTOR

- There are two types of cofactors:

1. **INORGANIC** ions [e.g., zinc or Cu(I) ions]
2. **ORGANIC** molecules known as coenzymes.

- Most coenzymes are vitamins or are derived from vitamins.
- **Vitamins** are organic compounds that are essential in very small (trace) amounts for the maintenance of normal metabolism. They generally cannot be synthesized at adequate levels by the body and must be obtained from the diet. The absence or shortage of a vitamin may result in a vitamin-deficiency disease.



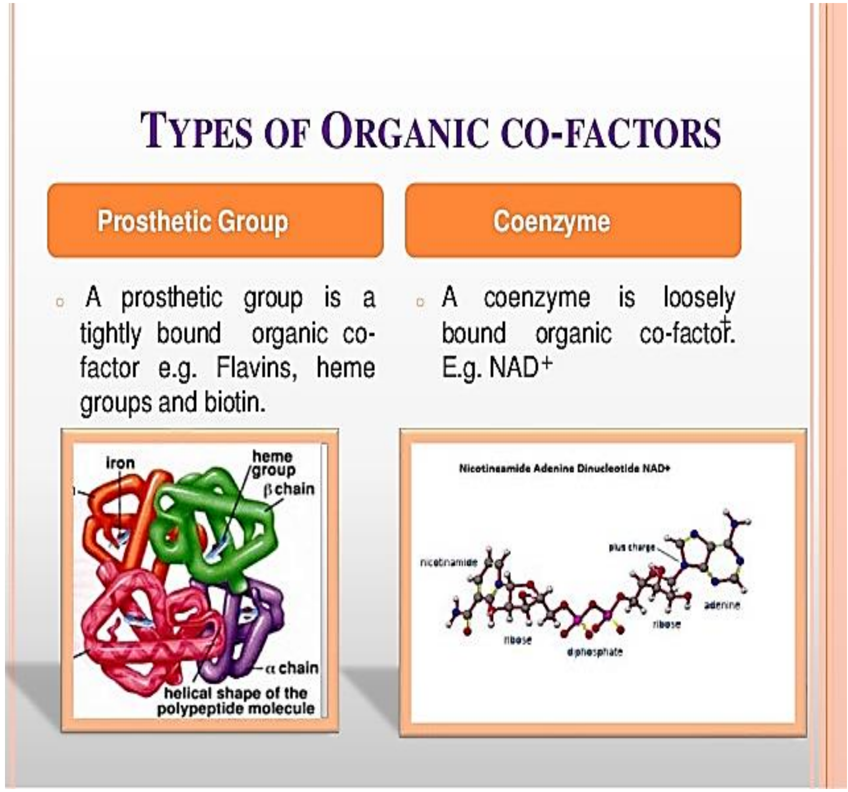
# Cofactor vs Coenzyme

| Coenzyme | Cofactor |
|---|---|
| **Meaning** | |
| It carries chemical groups between enzymes | They bind to an enzyme |
| **Also known as** | |
| Cosubstrates | Helper molecules |
| **Bind** | |
| Coenzyme loosely bound to enzymes | Some cofactors covalently bound the enzyme |
| **Removal** | |
| Can be easily removed | It can be removed only by denaturation |
| **Form** | |
| Chemical molecule | Chemical compound |
| **Characteristic** | |
| Organic substances | Inorganic substances |
| **Types** | |
| It is a type of cofactor | Two types of cofactors: Coenzyme and prosthetic groups |
| **Function** | |
| They act as carriers | Increase the speed of reaction |
| **Examples** | |
| Biotin, Vitamin, Coenzyme A | Metal ions such as $K^+$, $Zn^{2+}$ |

# ORGANIC CO-FACTOR

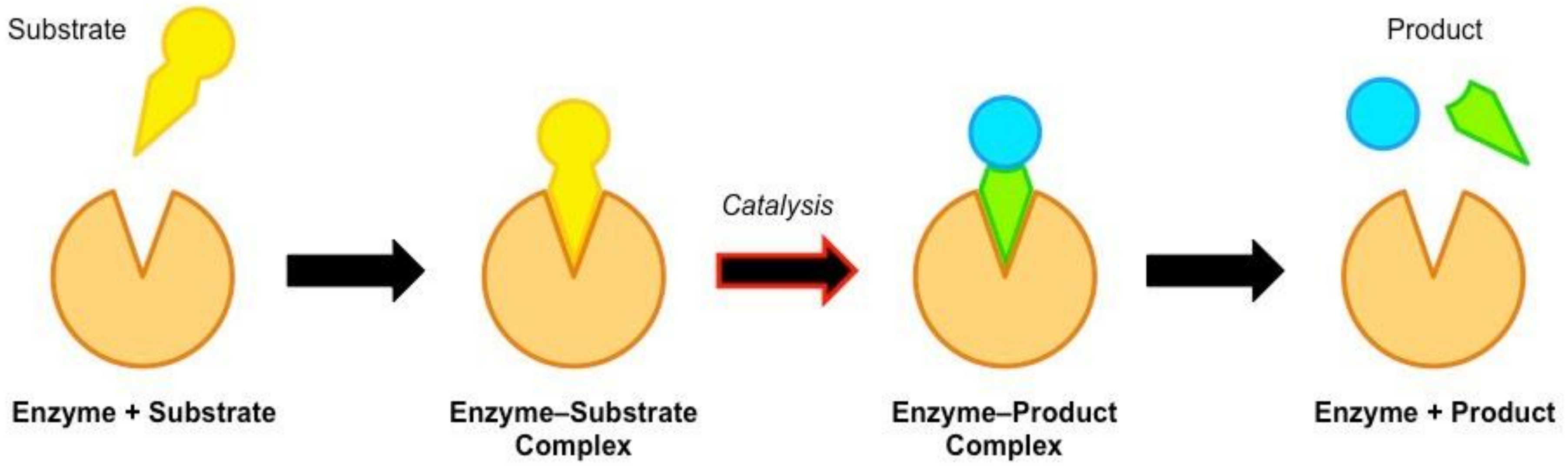
- **ORGANIC** molecules known as coenzymes.
- Organic cofactors are small organic molecules (typically a molecular mass less than 1000 Da) that can be either loosely or tightly bound to the enzyme and directly participate in the reaction.
- **Types of ORGANIC CO-FACTOR:**

1. **A prosthetic group:** is a tightly bound, specific non-polypeptide unit required for the biological function of some proteins. The prosthetic group may be organic (such as a vitamin, sugar, or lipid) or inorganic (such as a metal ion), but is not composed of amino acids.
2. **A coenzyme:** Is loosely bound organic co factor Eg: NAD+



# SUBSTRATE

- What is the substrate in an enzyme? In biochemistry, the substrate is a molecule upon which an enzyme acts. Enzymes catalyze chemical reactions involving the substrate(s). The substrate is transformed into one or more products, which are then released from the active site.



# ENZYME SPECIFICITY

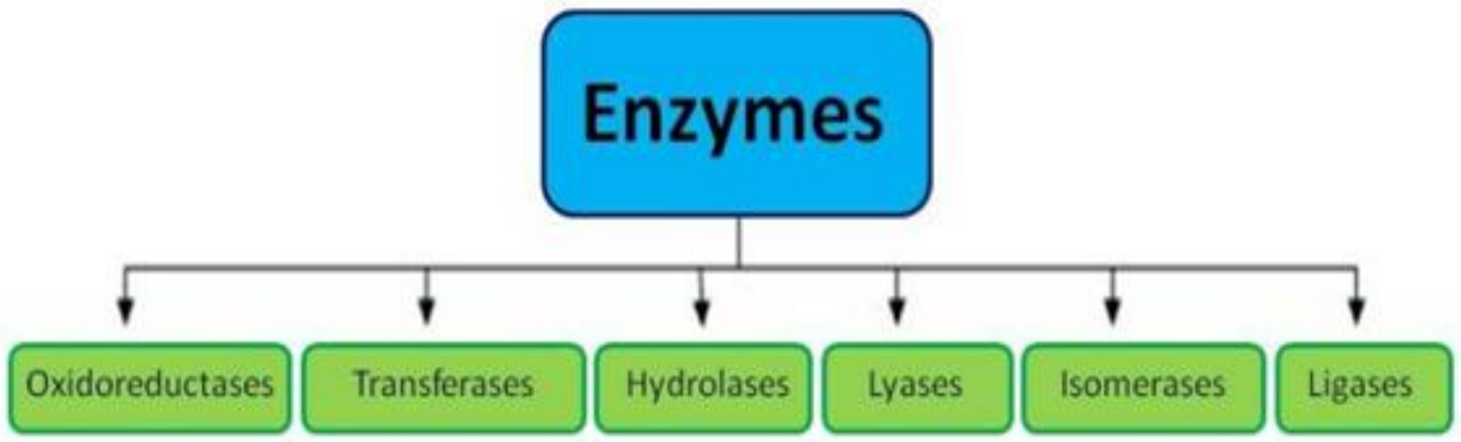
Enzymes may recognize and catalyze:

- A single substrate.
- A group of similar substrates.
- A particular type of bond.

**Table 21.2 Types of Enzyme Specificity**

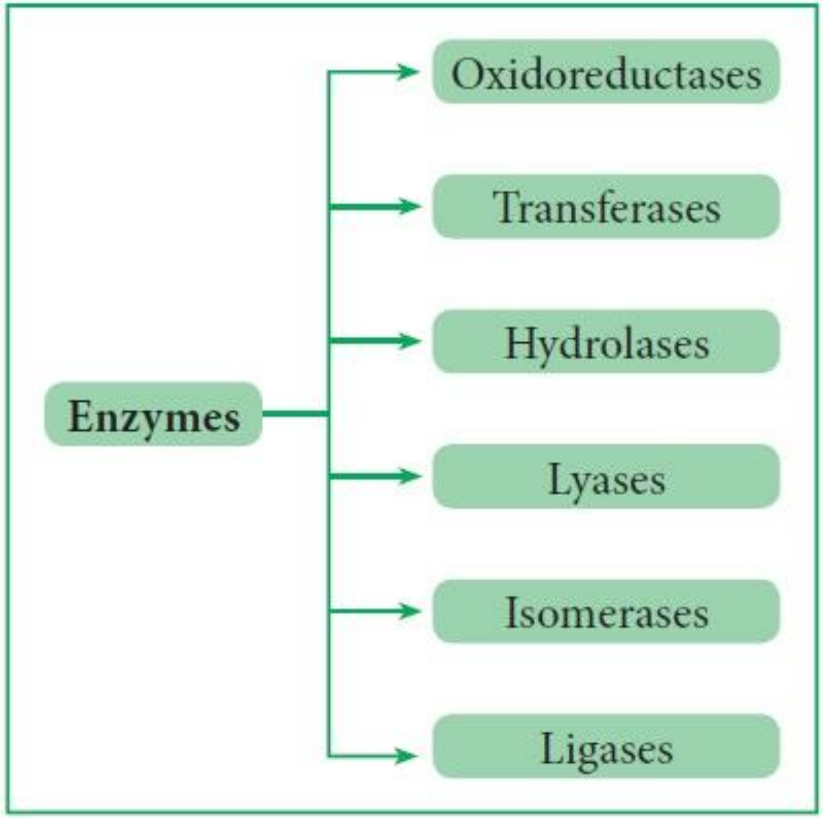
| Type | Reaction Type | Example |
|---|---|---|
| Absolute | Catalyze one type of reaction for a single substrate | Urease catalyzes only the hydrolysis of urea |
| Group | Catalyze one type of reaction for similar substrates | Hexokinase adds a phosphate group to hexoses |
| Linkage | Catalyze one type of reaction for a specific type of bond | Chymotrypsin catalyzes the hydrolysis of peptide bonds |

# Enzymes Classification



# Enzymes Classification

- Earlier, enzymes were assigned names based on the one who discovered them. With further research, classification became more comprehensive.
- According to the International Union of Biochemists (I U B), enzymes are divided into six functional classes and are classified based on the type of reaction in which they are used to catalyze.
- The six kinds of enzymes are:
- **HYDROLASES**
- **OXIDOREDUCTASES**
- **LYASES**
- **TRANSFERASES**
- **LIGASES AND**
- **ISOMERASES.**



# 1- Hydrolases

- Hydrolase is a class of enzymes that commonly perform as biochemical catalysts that use water to break a chemical bond, which typically results in dividing a larger molecule to smaller molecules. Some common examples of hydrolase enzymes are esterases , carbohydrases and Proteases.
- A–B + $H_2O$ → A–OH + B–H
- ***Found three Sub-class:***

1. **Esterases** is a hydrolase enzyme that splits esters into an acid and an alcohol in a chemical reaction with water called hydrolysis.

➢ RCO-OR + $H_2O$ esterase RCOOH (Acid) +ROH (Alcohol).

✓ Fats or Oils + $H_2O$ **lipase** → fatty acids + glycerol

✓ Chloropyll + $H_2O$ **chlorophylase** → chlorophylled + phytol

# 1- Hydrolases

**2. Carbohydrase** facilitates the hydrolysis of polysaccharides into simpler sugars called monosaccharides

**1- Maltase** reduces maltose into glucose: $C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$

Maltose + Water → 2 Glucose.

2- Starch + H2O $\xrightarrow{\text{amylase}}$ Dextrine $\xrightarrow{\text{dextrinase}}$ maltose $\xrightarrow{\text{maltase}}$ glucose

3- Sucrose + H2O $\xrightarrow{\text{sucrase}}$ glucose + fructose

# 1- Hydrolases

3. **Protease** (also called a peptidase or proteinase) is an enzyme that catalyzes the breakdown of proteins into smaller polypeptides or single amino acids. They do this by cleaving the peptide bonds within proteins by hydrolysis, a reaction where water breaks bonds

- Protein + $H_2O$ $\xrightarrow{\textbf{protinase}}$ Polypeptides
- Polypeptides + $H_2O$ $\xrightarrow{\textbf{polypeptidase}}$ Dipeptides
- Dipeptides + $H_2O$ $\xrightarrow{\textbf{dipeptidase}}$ Amino acids

# 2- Oxidation- Reduction enzymes

$RO + O_2 \rightarrow RO_2$ **( addition of oxygen)**

$RH_2 + A \rightarrow R + AH_2$ **( removal of hydrogen)**

$R^{++} \rightarrow R^{+++} + e^-$ **( loss of electron)**

**It have 4 sub class :**

- **Oxidases**
- **Peroxidases**
- **Dehydrogenase**
- **Catalase**

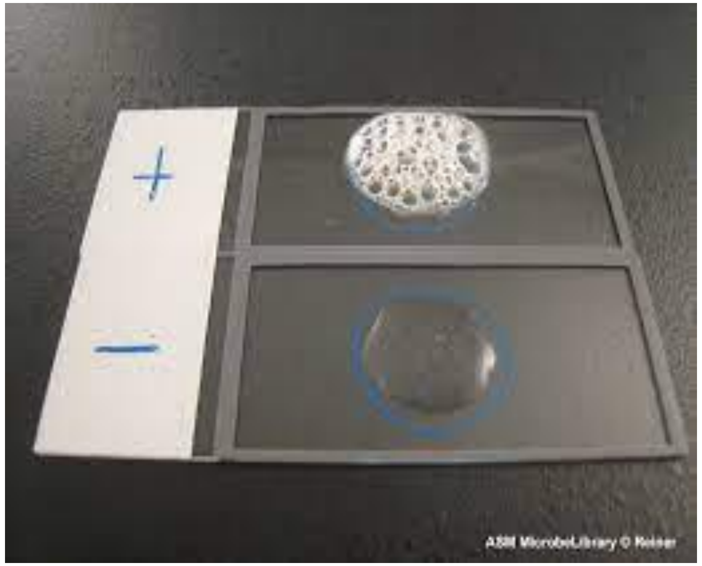
# 2- Oxidation- Reduction enzymes

## 1. Catalase

- Catalase action is decomposition of hydrogen peroxide in the living tissue

$$2\,H_2O_2 \longrightarrow 2\,H_2O + O_2.$$

- The presence of catalase in tissue sample can be tested by adding hydrogen peroxide and observing the reaction, the formation of oxygen bubbles indicates a positive result.



## 2- Oxidation- Reduction enzymes

### 2. Dehydrogenase

- Dehydrogenation of succinic acid to fumaric acid catalyzed by **succinate dehydrogenase**, FAD acting as a coenzyme.


- Another example of dehydrogenase is **Schardinger enzyme** which responsible for oxidation of formaldehyde to formic acid and reduction of M.B to leuco-M.B

$$HCHO + H2O + M.B \xrightarrow{\text{Schardinger enzyme}} HCOOH + M.B.H2$$

- **Alcohol dehydrogenase** yeast which responsible for ethyl alcohol oxidation to acetaldehyde in presence of co-enzyme acting as hydrogen acceptor

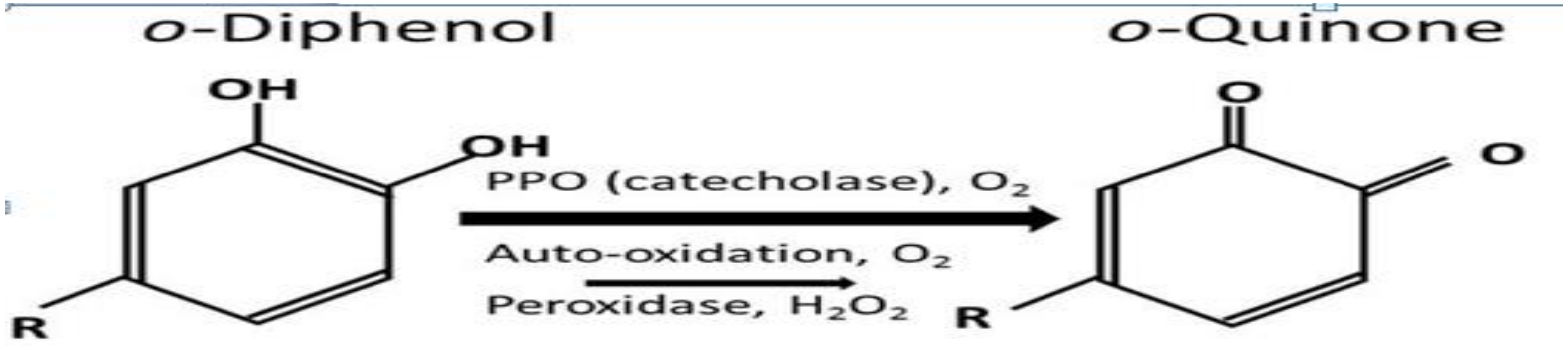
- $C2H5OH + \text{co-enzyme} \xrightarrow{\text{alcohol dehydrogenase}} CH3CHO + \text{Co-enzymeH2}$

# 2- Oxidation- Reduction enzymes

## 3. Oxidase and peroxidase

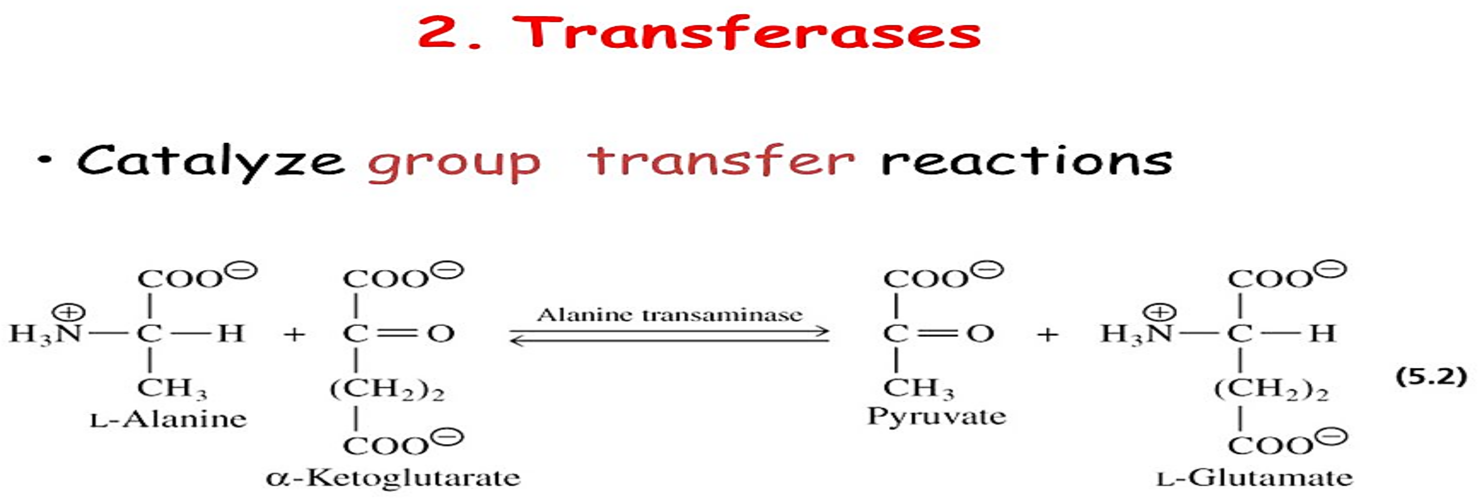
Polyphenol oxidase (PPO) and peroxidase (POD)

Enzymatic browning is one of the most important reactions that occur in fruits and vegetables, usually resulting in negative effects on color, taste, flavor, and nutritional value. The reaction is a consequence of phenolic compounds' oxidation by polyphenol oxidase (PPO), which triggers the generation of dark pigments. This is particularly relevant for apples, which are rich in polyphenols and highly susceptible to enzymatic browning.



# 3- Transferase

- A transferase
- one of a class of enzymes that transfer of specific functional groups (e.g. a methyl or glycosyl group) from one molecule (called the donor) to another (called the acceptor).
- Transamination, or the transfer of an amine (or NH2) group from an amino acid to a keto acid by an aminotransferase (also known as a "transaminase")



# 4- Lyases

- Lyases are enzymes that promote breaking of various chemical bonds by means other than hydrolysis.
- **Carboxy-lyases**, also known as decarboxylases, are carbon–carbon lyases that remove a carboxyl group from organic compounds.
- These enzymes catalyze the decarboxylation of amino acids.
- **Fructose-bisphosphate aldolase** (EC 4.1.2.13), often just aldolase, is an enzyme catalyzing a reversible reaction that splits the aldol, fructose 1,6-bisphosphate, into the triose phosphates dihydroxyacetone phosphate (DHAP) and glyceraldehyde 3-phosphate (G3P).

- **Zymase**
- $C_6H_{12}O_6 \xrightarrow{\text{zymase}} C_2H_5OH + CO_2$ + energy

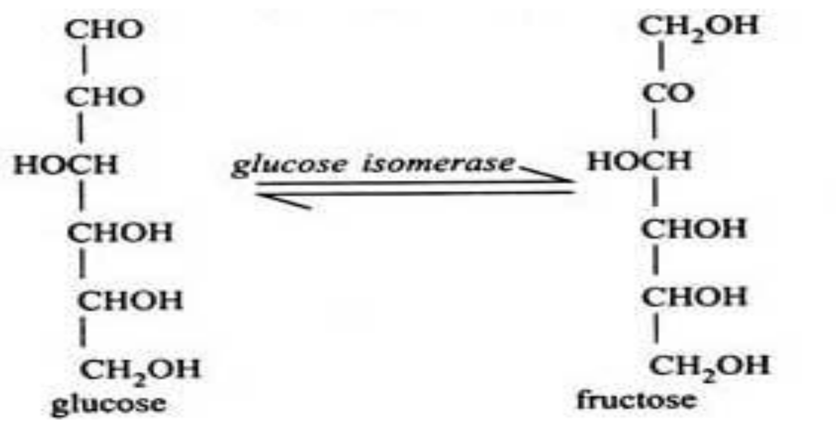
  glucose → ethyl alcohol

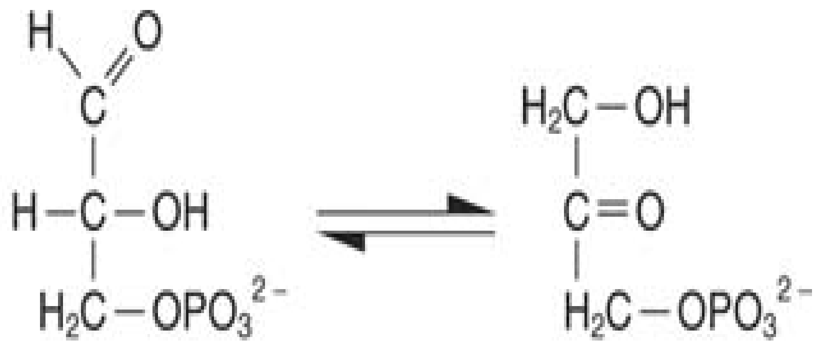
# 5- Isomerase

- Isomerases are a general class of enzymes that convert a molecule from one isomer to another. Isomerases facilitate intramolecular rearrangements in which bonds are broken and formed. The general form of such a reaction is as follows:

<u>**A–B → B–A**</u>

- There is only one substrate yielding one product. This product has the same molecular formula as the substrate but differs in bond connectivity or spatial arrangement. Isomerases catalyze reactions across many biological processes, such as in glycolysis and carbohydrate metabolism.




Glyceraldehyde-3-phosphate

Dihydroxy-acetone phosphate

# Carbohydrates metabolism

# Carbohydrates metabolism

- $CO_2$ photosynthesis converts in plants to monosaccharides and their derivatives, it is easy to deal with initiators of synthesis of oligosaccharides and polysaccharides.
- The most important oligo sugar is sucrose, through which fixed carbon and energy are transferred to the rest of the plant, where it creates two types of many sugars.
- They are: **structural polysaccharides**, such as cellulose, pectins, and **storage polysaccharides**, such as starch, fructans.
- The first type shows the plant cell walls
- And the kind that creates energies and stores permanent or permanent industry

# Carbohydrates metabolism

1- تحلل الجلوكوز Glycolysis

2- دورة كربس

3- بناء الجلايكوجين Glycogenesis

4- استحداث الجلايكوجين Gluconeogenesis

5- تحلل الجلايكوجين Glycogenolysis

# Carbohydrate metabolism includes two main processes:

**1- Building carbohydrates**

**2- Demolition of carbohydrates**

- **Carbohydrates Anabolism:** It takes place in the process of photosynthesis and takes place mainly in dark reactions, where carbon dioxide is reduced to sugar with the help of materials formed from light reactions.

- **Carbohydrates Catabolism:** in the process of respiration, specifically in the process of decomposing glucose and the Krebs cycle.

- Carbohydrates are substances that contain carbon, hydrogen and oxygen in a 1:2:1 ratio
- The ratio of hydrogen and oxygen is the same as their presence in water
- Deviations from this rule are some substances such as acetic acid

# Benefits of carbohydrates

1. A large source of energy, as its decomposition and oxidation produce energy that is used in biochemical reactions.
2. The chemical energy derived from carbohydrates is stored in the form of energy-rich compounds such as adenosine triphosphate (ATP) and guansine triphosphate (GTP).
3. Carbohydrates are part of the cell wall structure.

## A - Methods of Classification:

Several methods are used to classify carbohydrates.

*1-One method of classification is based on whether the carbohydrate can be broken down into smaller units.*

- Monosaccharides

cannot be broken down into smaller units by hydrolysis. Sometimes called simple sugars.

- Disaccharides

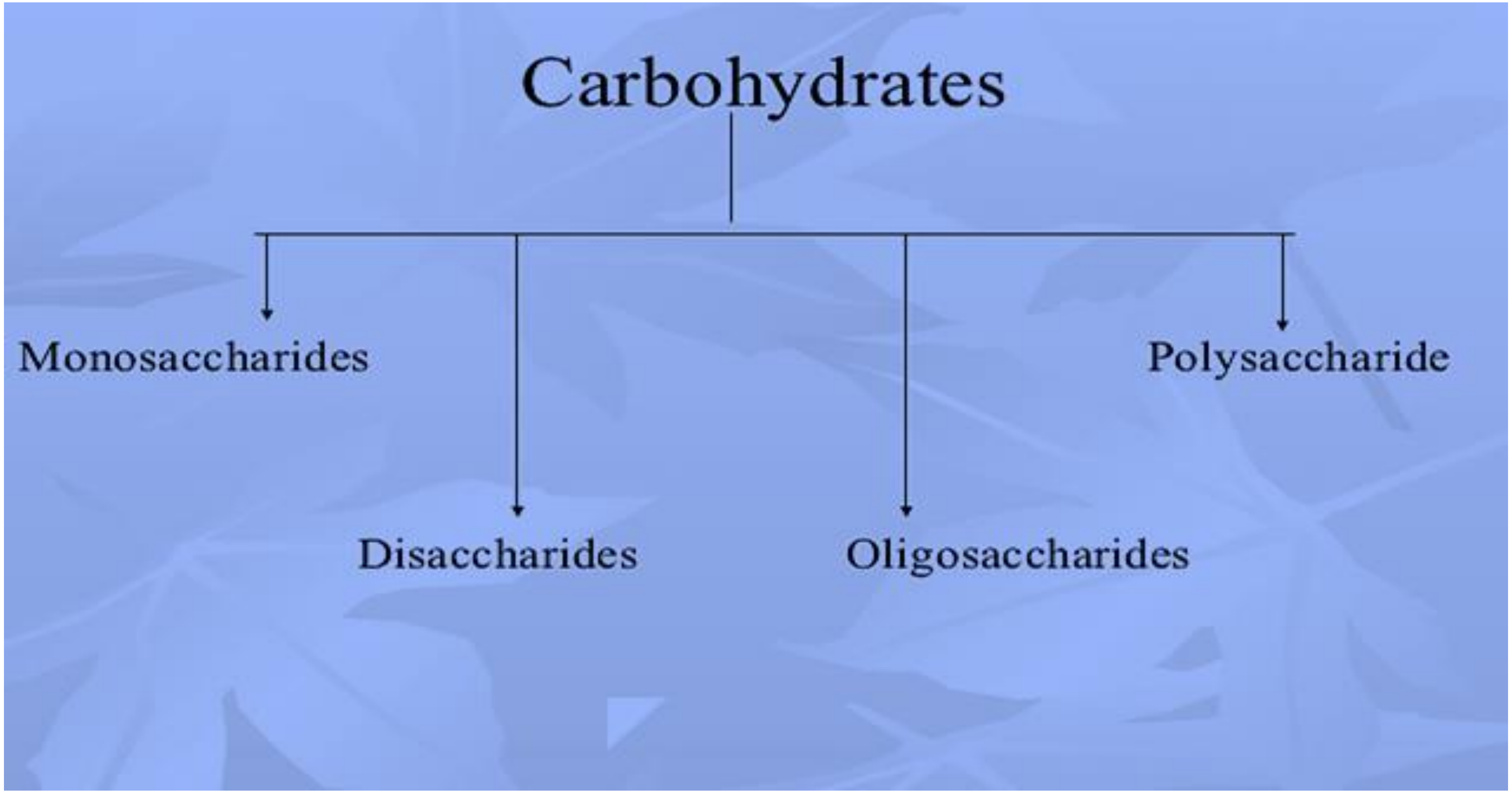
can be broken down (hydrolyzed) into two monosaccharide units.

- Oligosaccharides

can be broken into three to six monosaccharide units.

- Polysaccharides

composed of 7 or more mono-saccharide units.


Carbohydrates
Monosaccharides
Disaccharides
Oligosaccharides
Polysaccharide

# 1. Monosaccharides

They are the simplest types of carbohydrates, as they consist of one sugar molecule, which are the units from which the rest of the other types of carbohydrates (binary - limited - many) are composed and contain a chain of carbon atoms ranging from 3 to 7 atoms, including:

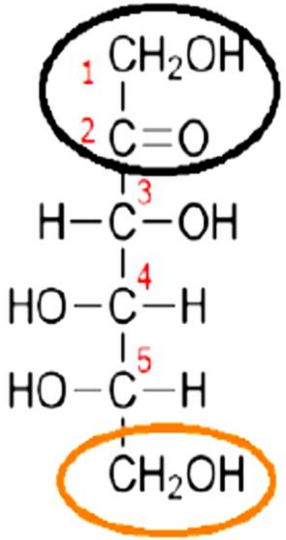
١- السكريات الثلاثية TRIOSES

٢- السكريات الرباعية TETROSES

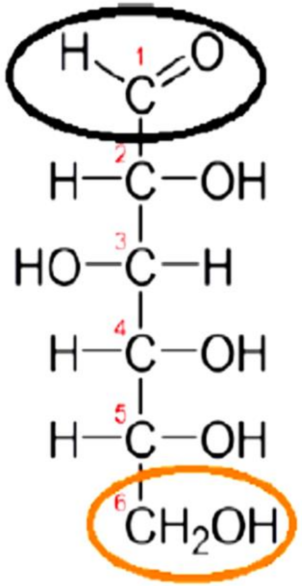
٣- السكريات الخماسية PENTOSES

٤- السكريات السداسية HEXOSES

٥- السكريات السباعية HEPTOSES



ketose
fructose



aldose
glucose

| MONOSACCHARIDE | ALDOSES | KETOSES |
|---|---|---|
| Trioses ($C_3H_6O_3$) | Glycerose (glyceraldehyde) | Dihydroxyacetone |
| Tetroses ($C_4H_8O_4$) | Erythrose | Erythrulose |
| Pentoses ($C_5H_{10}O_5$) | Ribose, Arabinose, Xylose | Ribulose, Xylulose |
| Hexoses ($C_6H_{12}O_6$) | Glucose, Galactose. Mannose | Fructose |
| Heptoses ($C_7H_{14}O_7$) | --------------- | Sedoheptulose |

# Examples of Monosaccharides:

**Pentoses** such as:

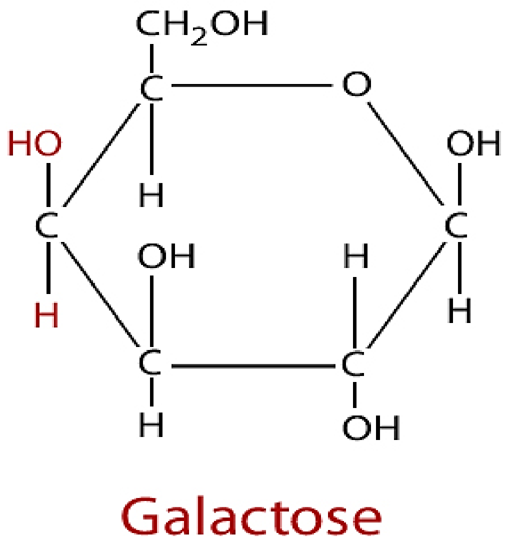
**Ribose**: It is included in the synthesis of DNA.

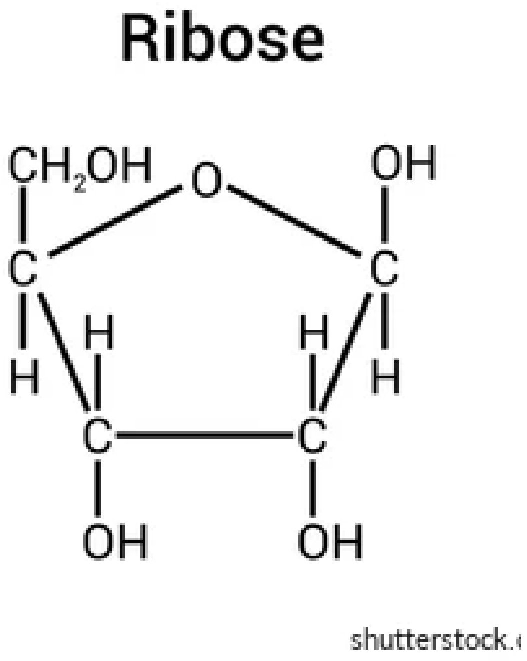
**Hexoses** such as:

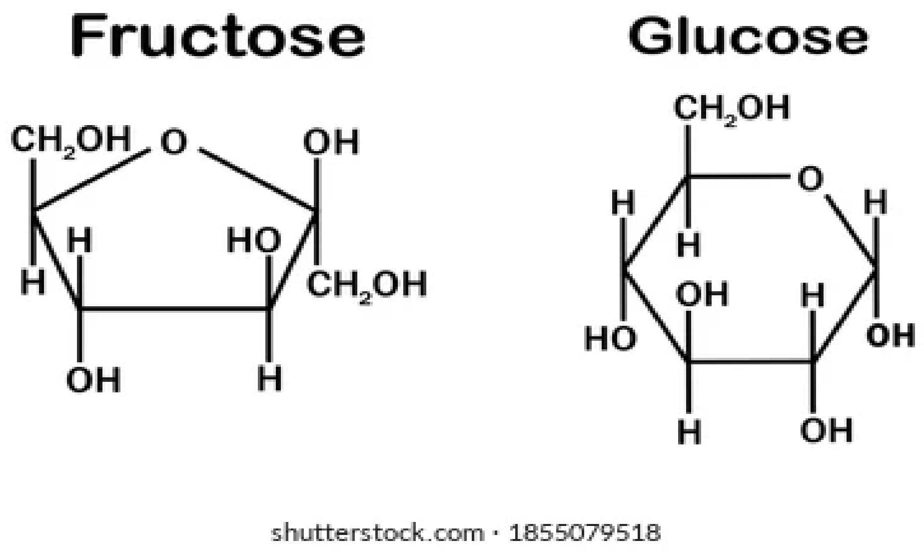
**Glucose**: a great source of the energy you need

**Fructose**: turns into glucose, which is used in metabolic processes

**Galactose**: converted to glucose for metabolic processes.



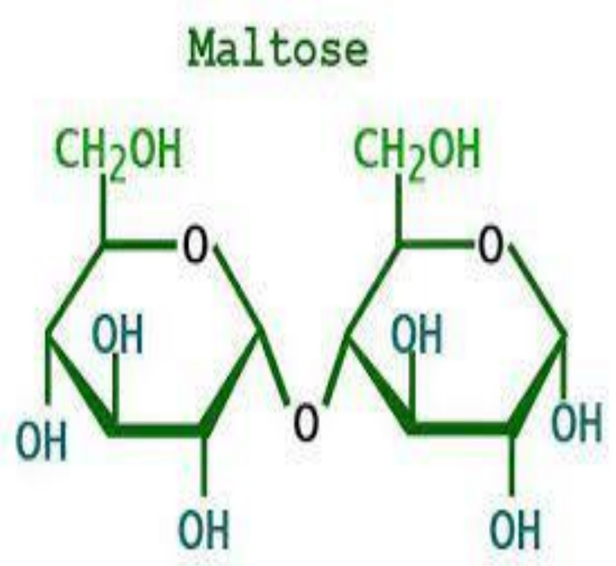



# 2. Disaccharides

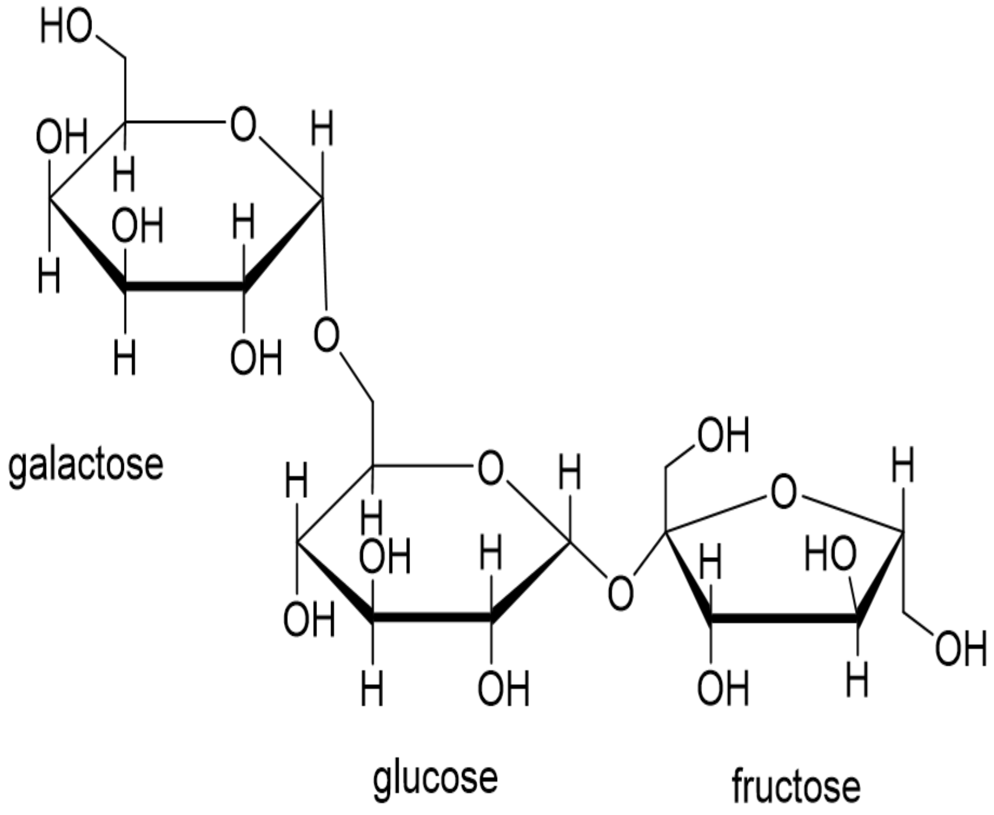
- They are the sugars resulting from the union of two monosaccharides, with the general symbol $C_{12}H_{22}O_{11}$, the most important of which are sucrose, maltose and lactose.
- <u>For example : maltose</u>

Maltose consists of two glucose molecules linked by a glycosidic bond resulting from the bonding of the carbon number (1) atom with the carbon number (4) in the other molecule, and this bonding results in the loss of a water molecule. glucose



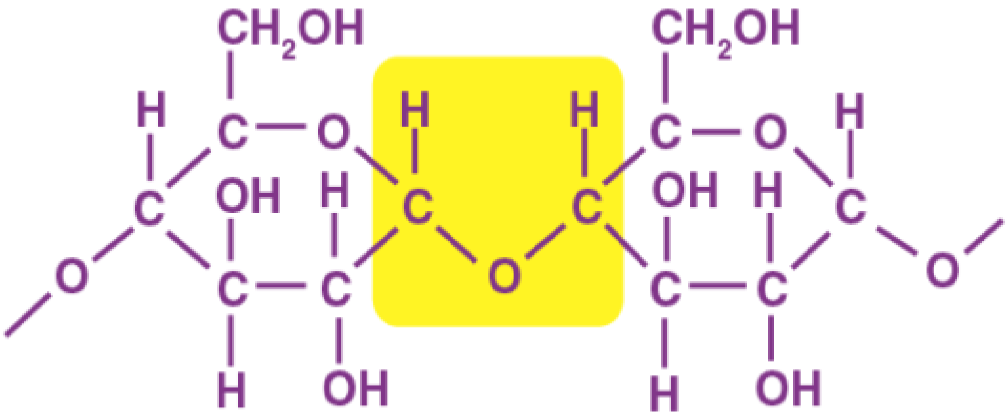
# 3. Oligosaccharides

In it, the number of monosaccharides that make up the chain ranges between 3-9 units, including **raffinose**, which is a limited sugar consisting of three molecules of glucose, fructose and galactose.



# 4. Polysaccharides

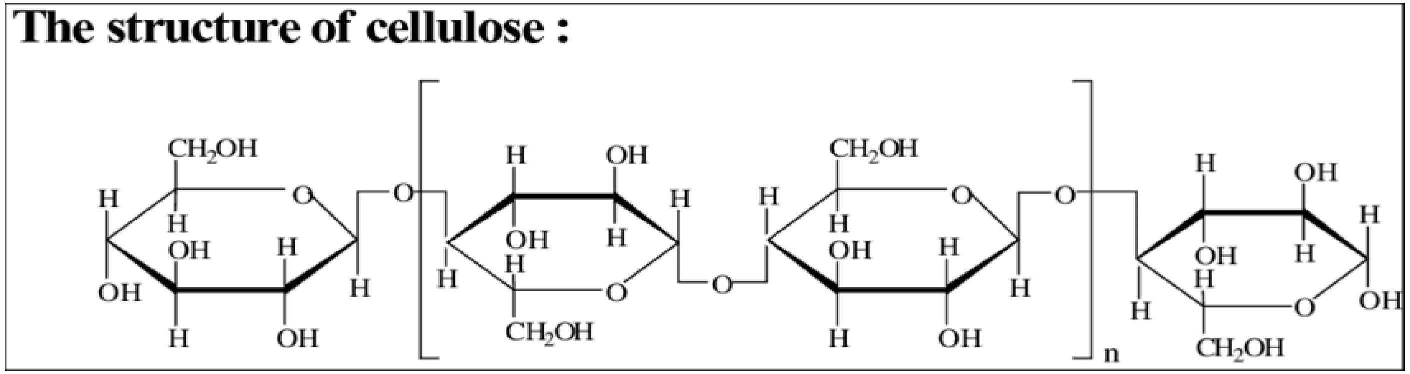
They are sugars in which the number of monosaccharides in the chain is 10 units or more. There are two types of polysaccharides most common in plants:



Simple starch

1- Starch

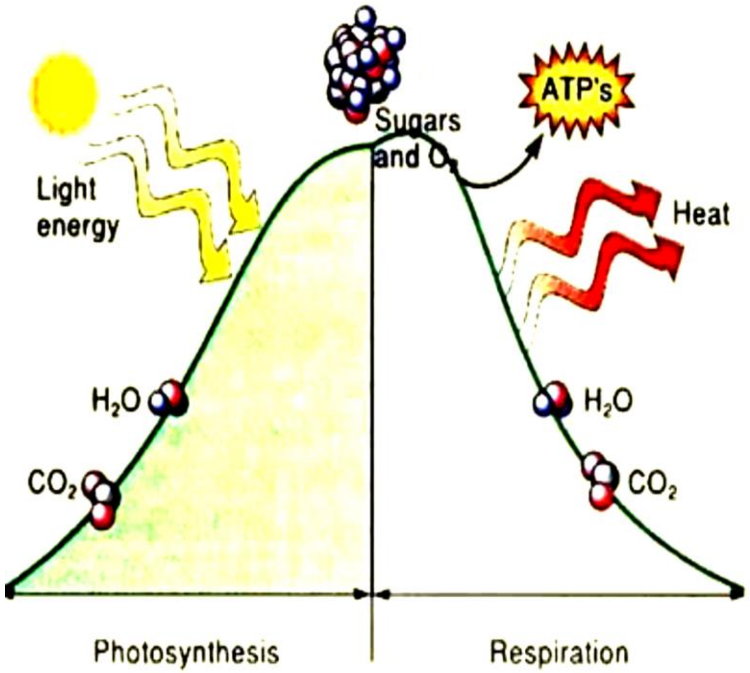
2- Cellulose



# The Respiration

# The Respiration

- Living organisms derive energy stored in organic compounds during their oxidation and disintegration.
- The stored energy is released into an active energy state that is used in various biological processes, as well as in the activation of some chemical compounds to form new compounds that contribute to increasing the amount of protoplasm and thus the growth of the organism.
- The process of disintegration and oxidation of organic compounds and the release of the stored energy in them into a state of free energy is known as the process of respiration and the process.
- Respiration is an **oxidation** and **reduction** process that occurs in all living cells, causing the release of potential energy in the reactants on an active energy state, and therefore it is the opposite of the building process known as photosynthesis and gives opposite products.



# The Respiration

$$C_6H_{12}O_6(\text{Glucose}) + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{Energy}$$

- Respiratory cells are able to exploit the resulting energy and convert it into the energy itself while it is used for growth, building and perpetuation purposes.
- The equation does not represent the reality of the respiration process that takes place inside living cells, as the respiration process is within living cells, as the respiration process is a group of common chemical factors, and each enzyme helps it or makes it a valuable exchange agent for the other.
- The fragmentation of macromolecules of chemokines that can be considered to be at the base of the cell.

# The Respiration

- **Some of these intermediate compounds are transformed into:**

1. Amino acids, which in turn are involved in the synthesis of proteins
2. Others are converted by the cell into nucleotides that are involved in the synthesis of DNA and RNA
3. The other part of these compounds turns into fatty acids, which in turn enter into the composition of Lipids
4. Also, these intermediate compounds are the carbon sources of many pigments such as porphyrin, cytochromes, citrullates, and to many aromatic compounds.

# The Respiration

- **Another Definition :**

1- The process of respiration is defined as the breakdown of complex compounds formed in the process of photosynthesis and the extraction of energy from this process for use in the vital processes that occur in the living organism in the presence of oxygen, and this is called aerobic respiration.

2- If this process takes place in the absence of oxygen, it is known as anaerobic respiration or alcoholic fermentation.

**Reaction**

$$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{Enzymes}} 6H_2O + 6CO_2 + 686\ \text{Kcal or } 38\ \text{ATP}$$

# Respiratory Quotient ( RQ)

$$RQ = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen consumed}}$$

- It is the ratio of carbon dioxide released to absorbed oxygen .
- The value of the respiration factor varies according to the substance used in respiration. If the substance used is:

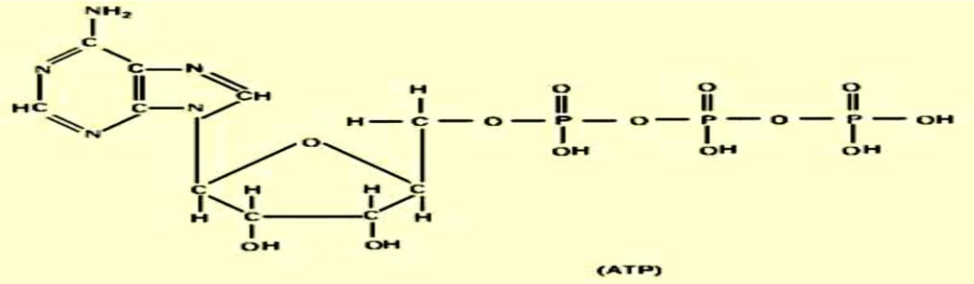
1- **A carbohydrate substance**, the respiration coefficient = 1, where the plant consumes one molecule of oxygen for every molecule of carbon dioxide released.

2- **A fatty substance**, the respiration coefficient is less than one, about 0.7, as fatty substances are more reduced than carbohydrates, and therefore the process of respiration needs more oxygen to oxidize fatty substances.

3- **Organic acids** have a respiration coefficient higher than one.

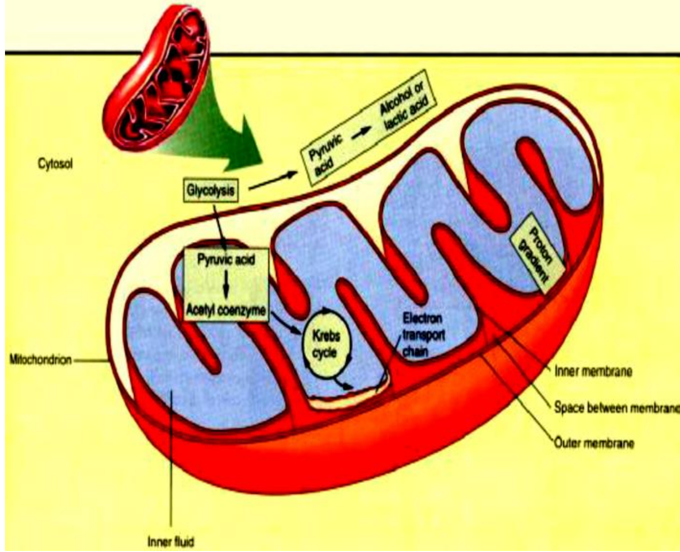
# The process of energy transfer within plants

- The general method of energy transfer in living organisms depends on the presence of phosphorylated compounds such as:
- Adenosine triphosphate (ATP) and adenosine diphosphate (ADP) can store and transport energy.
- The main part in these compounds is the **adenosine** compound, which consists of the compound **Purines** linked to ribose sugar and three groups of phosphoric acid as in the case of (ATP) and two groups of acid in the case of (ADP) and is linked by an ester bond.



# The location of the Respiration

- Respiration takes place in small organisms known as the mitochondria, which is the house of energy, as it contains the respiration enzymes, which are bodies surrounded by two units of membranes that contain the cytoplasm, the enzymes of the Krebs cycle, and many compounds from the products of enzymatic reactions and cytochromes,.
- Because mitochondria contain DNA, they have the ability to divide without relying on the nucleus.

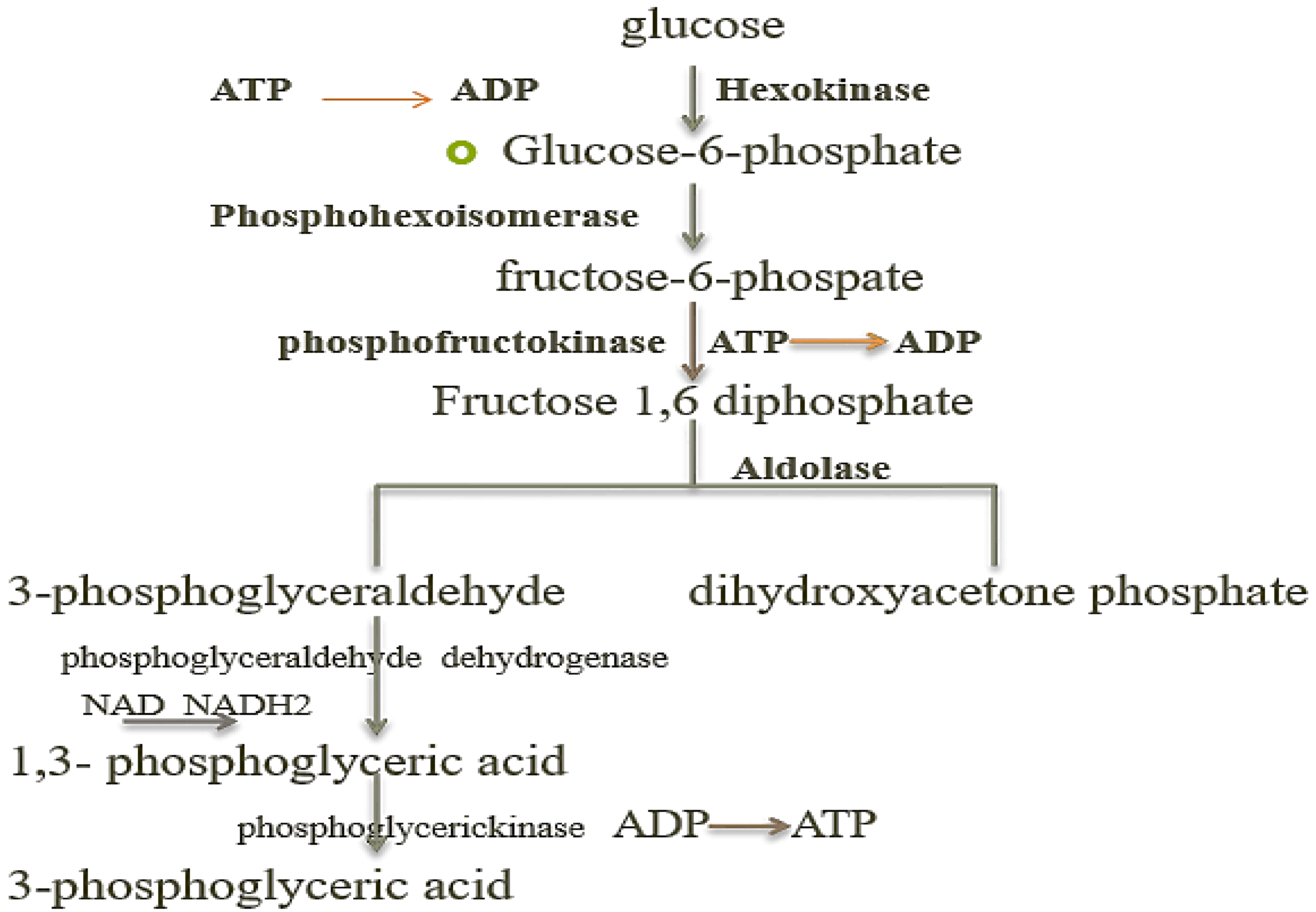


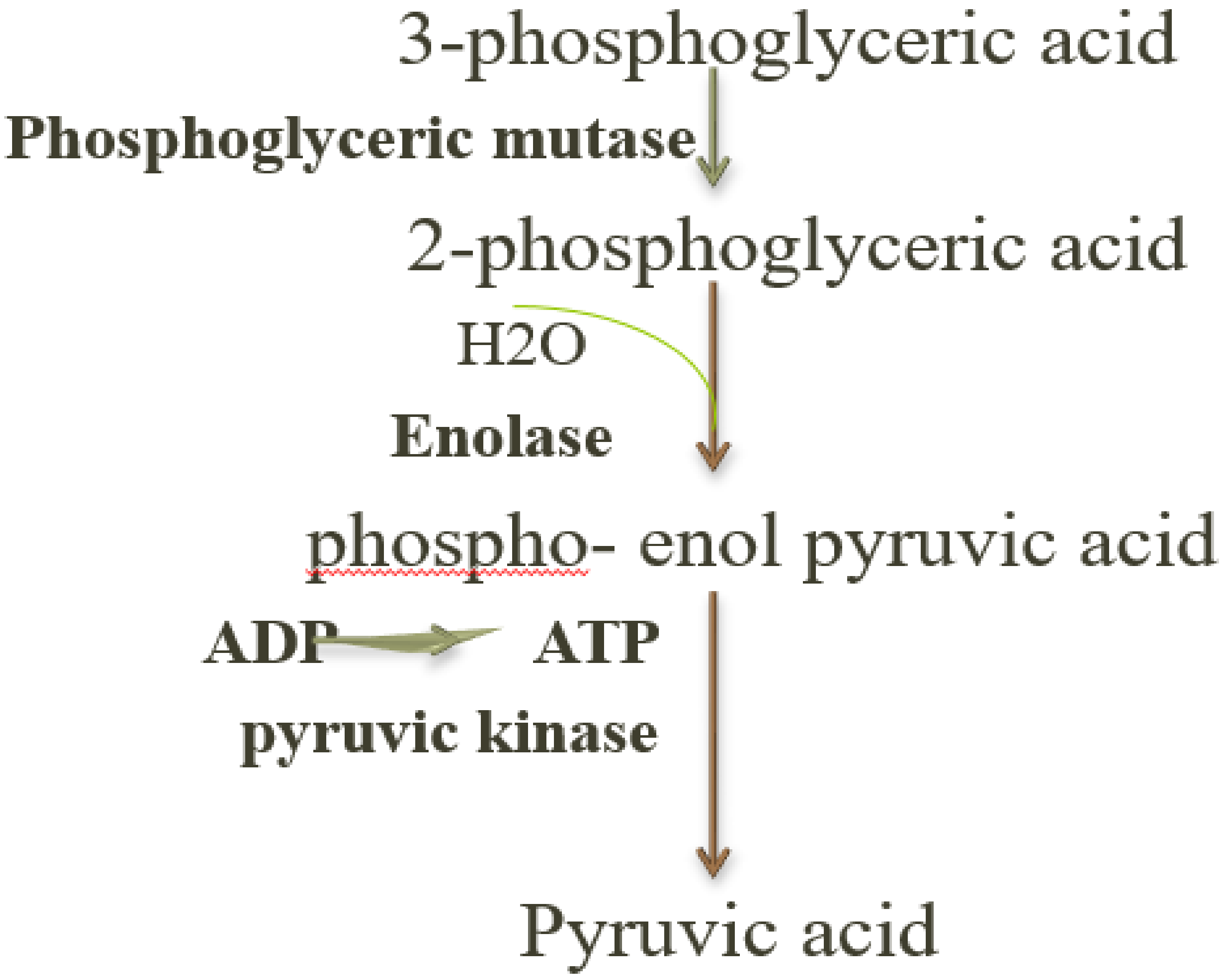
# Respiratory mechanics

- The process of respiration in plants takes place through a huge number of reactions, which can be divided into three main stages:
- 1- The stage of sugar breakdown or **glycolysis**, which takes place in the cytoplasm
- 2- The **Kreb's Cycle**, which takes place in the mitochondria
- 3- **The respiratory chain**, which takes place in the mitochondria

# <u>The first stage</u>: sugar breakdown or glycolysis and takes place in the cytoplasm (Glycolysis)

- The plant breaks the hexagonal sugar into 2 molecules of pyruvic acid and takes place in two stages:
- 1- Converting glucose into fructose 1,6-diphosphate
- 2- Converting fructose 1,6-diphosphate to 2 moles of pyruvic acid


glucose
ATP
ADP
Hexokinase
Glucose-6-phosphate
Phosphohexoisomerase
fructose-6-phospate
phosphofructokinase
ATP
ADP
Fructose 1,6 diphosphate
Aldolase
3-phosphoglyceraldehyde
dihydroxyacetone phosphate
phosphoglyceraldehyde dehydrogenase
NAD NADH2
1,3- phosphoglyceric acid
phosphoglycerickinase
ADP
ATP
3-phosphoglyceric acid

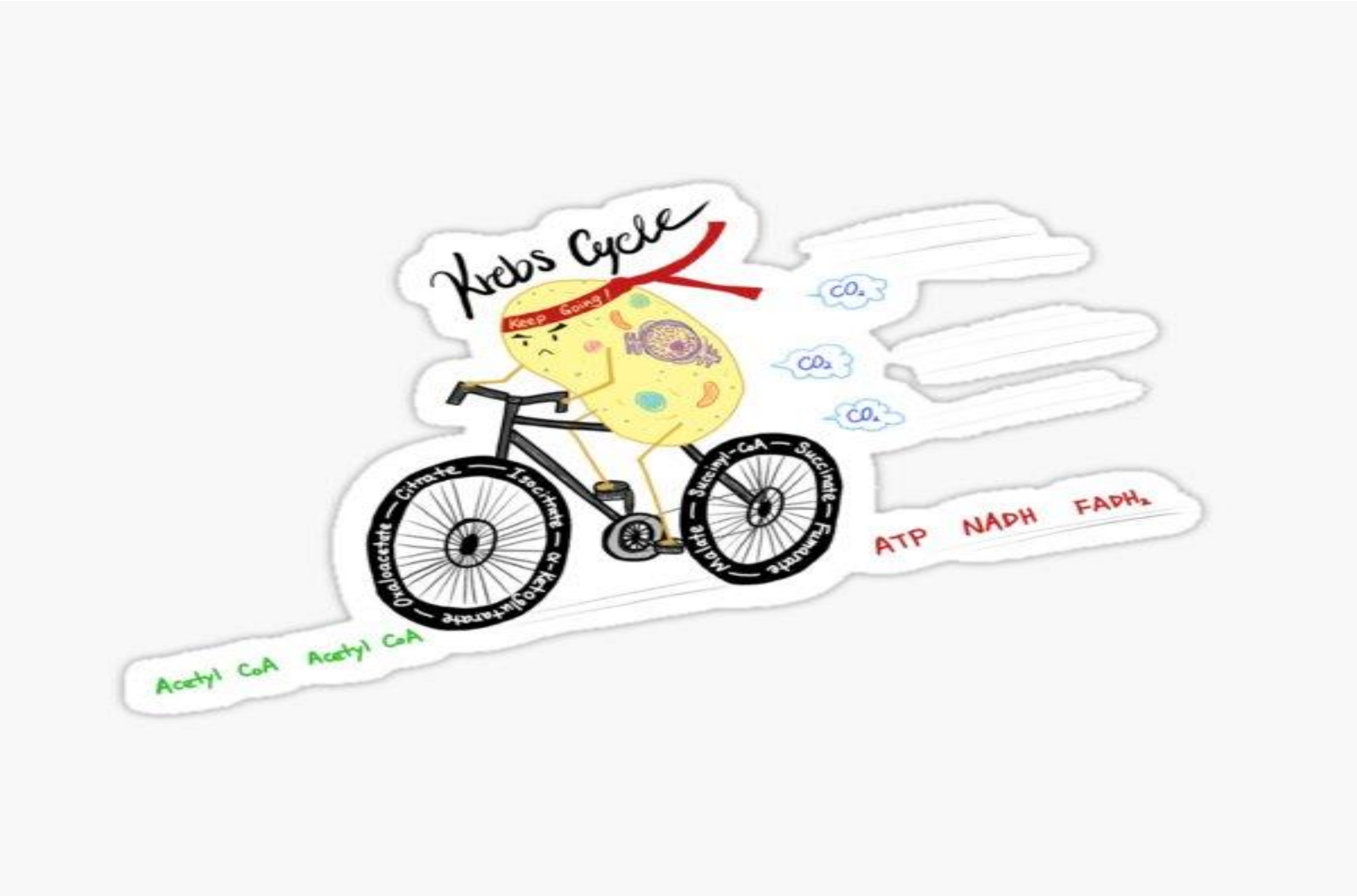

3-phosphoglyceric acid
Phosphoglyceric mutase
2-phosphoglyceric acid
H2O
Enolase
phospho- enol pyruvic acid
ADP
ATP
pyruvic kinase
Pyruvic acid

- At this step, the first stage of the respiration process ends, which is an anaerobic stage and is also the first stage in the anaerobic respiration process (in the end it will be 2 molecules of ATP and 2 molecules of NADH2)
- Pyruvic acid is converted to **acetaldehyde** and carbon dioxide is escalated in the presence of the enzyme carboxylase

**The next step depends on whether or not there is oxygen**

- In the absence of oxygen, acetaldehyde is reduced to ethyl alcohol in the presence of alcoholic dehydrogenase and NADH2.
- In the presence of oxygen, acetaldehyde enters the second stage, the Krebs cycle, to convert to carbon dioxide, and reducing substances NADH2 and FADH2 are formed.
- It is re-oxidized in the respiratory chain and as a result energy is released

# The Second Stage Krebs cycle



# Factors affecting respiratory rate

## 1- Oxygen:

It is clear that the lack of oxygen in the atmosphere surrounding plants that usually breathe aerobic respiration has harmful effects on these plants, and the extent of damage varies according to the type of plant or tissue, its age, and the duration of exposure to these anaerobic conditions. These damages occur due to many factors, including the lack of energy obtained through anaerobic respiration. Accumulation of some harmful or toxic products in the organism.


In general, oxygen is not considered a specific factor for respiration under normal conditions, as its concentration in the atmosphere is very sufficient for aerobic respiration and is considered fairly stable.

# Factors affecting respiratory rate

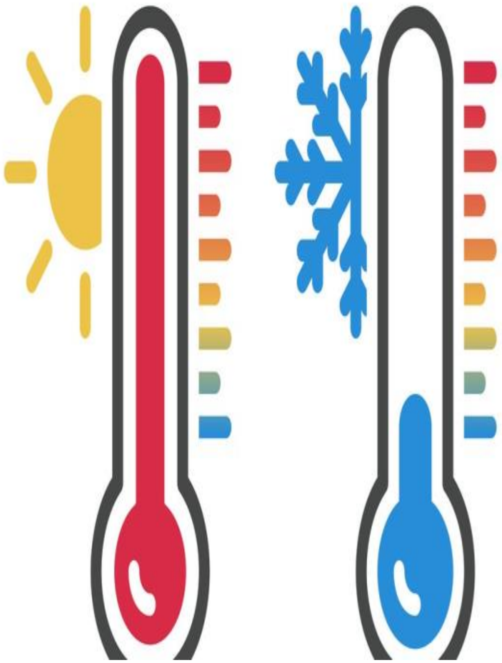
## 2- Temperature:

The effects of heat on the respiratory rate are due to many interrelated factors, and in general it can be said that increasing the temperature significantly increases the speed of the breathing process.

It must be taken into account that the plants, and even the organs, differ among themselves in their responses to heat, but it was observed that most of the plant tissues increase their respiration speed when the temperature exceeds 35 degrees Celsius.

This effect remains for certain periods only, as the continuation exposes the plant to harmful adverse effects and is often due to slowing down or nullifying the work of enzymes and the rest of the protein components in the cytoplasm.

The continuation of the high temperature may be a reason for the accumulation of some reaction products such as carbon dioxide gas, and its concentration may increase to a rate that is harmful or toxic to the cells. Alive as a result of the rapid breathing process.



# Factors affecting respiratory rate

## 3- Carbon dioxide concentration:

By increasing the concentration of $CO_2$ in the cells, the action of enzymes related to the removal of $CO_2$ molecules from carbohydrate compounds is reduced or invalidated.

Also, an increase in the concentration of $CO_2$ leads to an increase in the acidity of the cell juice and the cytoplasm of the cell, which has a profound effect on the accumulation and type of different enzymatic reactions and the speed of their completion.

However, due to the relatively constant concentration of carbon dioxide in the air, the effect of the poison is concentrated mainly on the ground parts of the plant as well as microorganisms, as in poorly ventilated soil its concentration increases and oxygen decreases, which slows down the work of the roots in the active absorption of nutrients.

# Factors affecting respiratory rate

## 4- Nutrients:

It was observed from the aforementioned reactions regarding anaerobic and aerobic respiration that most of the enzymes controlling these reactions require enzymatic aids from some mineral elements such as: Fe, Cl, Mg, Mn

Magnesium is required for the reactions of phosphorylation and the reaction of K2 removal, where potassium acts as an enzyme cofactor in the reaction of producing pyruvic acid, while iron does the same work in the reaction of converting citric acid to isocitric acid in aerobic respiration, and even manganese acts as a cofactor for the enzyme controlling the production of oxalic acid

## Factors affecting respiratory rate

### 5- Light:

Light is considered one of the factors affecting, directly or indirectly, the respiration. The light increases the temperature of the tissues, which leads to an increase in the respiration process.

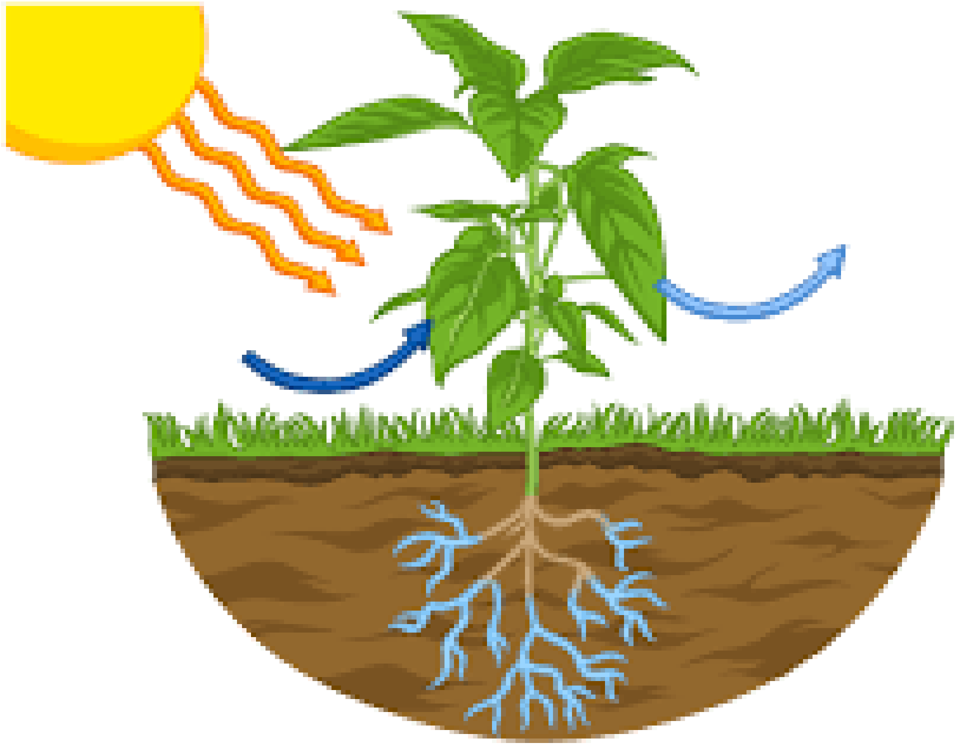
The high light intensity encourages the process of photosynthesis, and thus the concentrations of sugars produced and necessary as a reaction material for the respiration process increase.

### 6- The degree of wetness of the tissues:

The higher the tissue moisture, the higher the respiration rate, usually due to the increase in the enzymes' need for high water contents. It was observed that the lower the water content, the lower the respiration rate, as in dry seeds.

Also, the lack of moisture affects the degree of permeability of plasma membranes to gases, and therefore the lack of oxygen will be a limiting factor, while the increase in carbon dioxide will become a harmful or hindering factor for the breathing process.

# Photosynthesis



# 1- Definition of photosynthesis

The word Photosynthesis comes from Photo, which means light, and Synthesis, which means building.

It is a physiological phenomenon that allows the direct capture of part of the light energy by the plant, as the captured energy mainly serves in the internal construction of large organic molecules, starting from the main materials that are air carbon gas, water, and soil minerals. The return of carbon gas in organic compounds requires the provision of energy, which is secured by green plants and some bacteria by using light energy, and the pigment responsible for this representation is chlorophyll.

This physiological phenomenon in all its scope is more important than everything that happens in the living medium, and the abolition of photosynthesis from a region of the earth by the intensive use of toxic chemicals for the plants of the medium causes an imbalance in the environmental balance and turns the region into a desert.

## 2- The importance of photosynthesis:

Most living organisms live at the expense of material wealth and energy on Earth, for which the sun is the only source. The most important plant that can convert light energy emitted from the sun into chemical energy is green plants that store energy in the form of complex organic compounds that make up their cellular structure. Humans and animals exploit these organic compounds in building their bodies, where they oxidize them and convert them into kinetic energy.

# 3 - The photosynthetic apparatus;

Most of the photosynthesis processes take place in green leaves, as their anatomical structure helps them to carry out this process efficiently. The protoplasm of the columnar and spongy mesophyll cells contains large numbers of chloroplasts, with an average of 100 plastids in each cell, and each chloroplast is considered a complete device that can carry out a process Photosynthesis independently, as it contains all the enzymes and compounds necessary to carry out this important vital process.

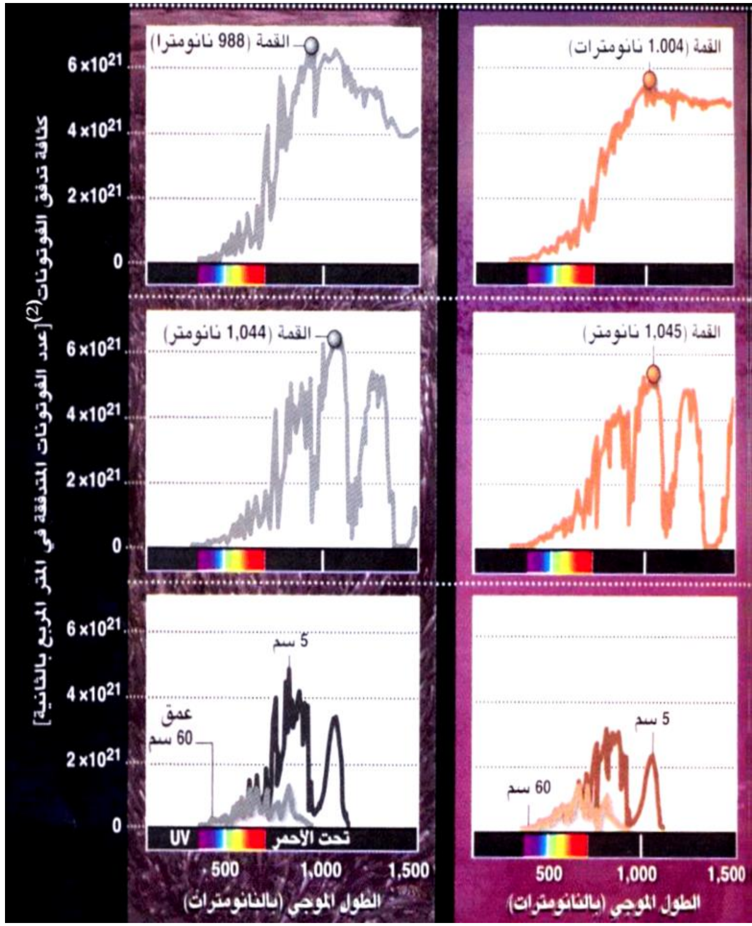
# 4- The nature of light:

Light is defined as electromagnetic radiation that can be perceived by the human eye, and the visible spectrum constitutes a small part of these radiations. Frequent and regular changes in the strength of magnetic fields indicate the passage of light waves.

Light can pass through solid objects (types of plastic), liquids (water, air gases, and the vacuum layer between the sun and the earth). In nanometers and meters, light waves are considered a path for very small particles, which are photons, each of which can be represented by a small bag filled with a specific energy that depends on the type of light.

The energy of a photon is called a quantum, and the energy is inversely proportional to the wavelength.

For example, the quantum value in ultraviolet radiation with a wavelength of 100 nanometers is 4 times greater than the quantum value in ultraviolet radiation with a wavelength of 400 nanometers.



# 4- The nature of light:

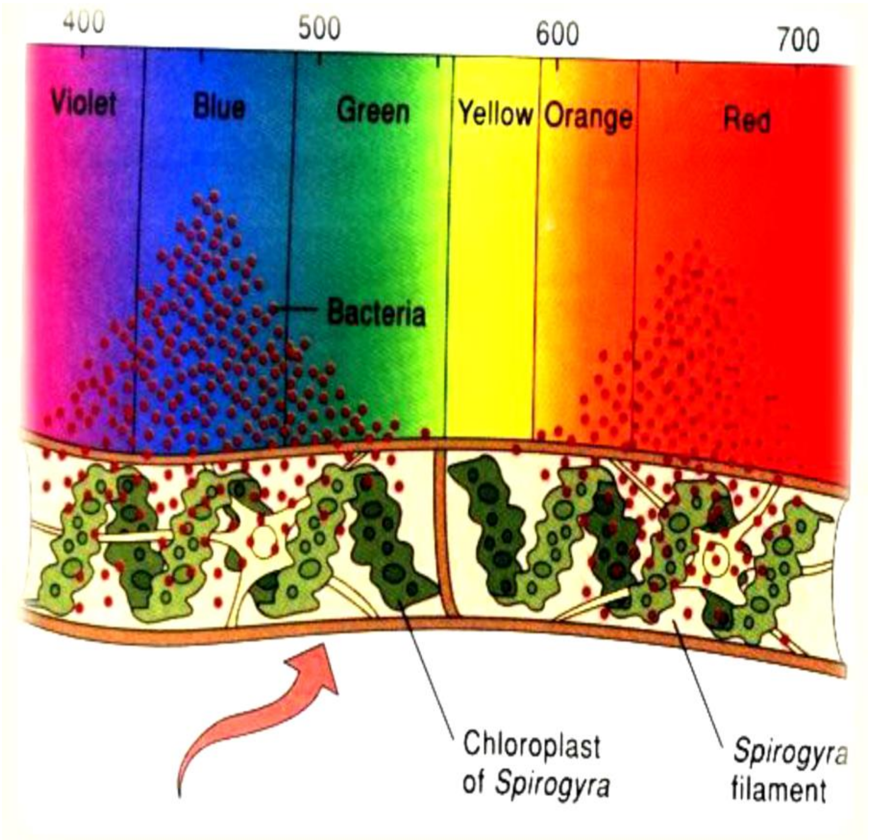
When hydrogen is converted to helium in the body of the sun, different types of rays are released. Despite these differences between the types of rays, they are generally considered as part of the energy of the continuous spectra, which differ among themselves in the wavelength of those rays. The field of visible light extends from a wavelength of approximately 400 to 700 millimeters.

These waves are considered a path for tiny particles that are photons, each of which can be represented by a small bag filled with a specific energy (depending on the type of light).

The collision of these photons with the plant dyes that have lost their energy and the dye acquires them, and the electrons located in different levels around the nuclei of the atoms of these dyes move to levels of energy higher than the level in which they were located.

The second, after which the electron falls to the field of the previous one that is less active (i.e. closer to the nucleus), and the energy resulting from the loss of this electron for energy is unique to a specific action, and this energy, which is called the activation energy, is released in the form of reflected heat, or by giving this energy to another compound, or it is exploited in a specific chemical reaction It also occurs in oxidation and reduction processes.

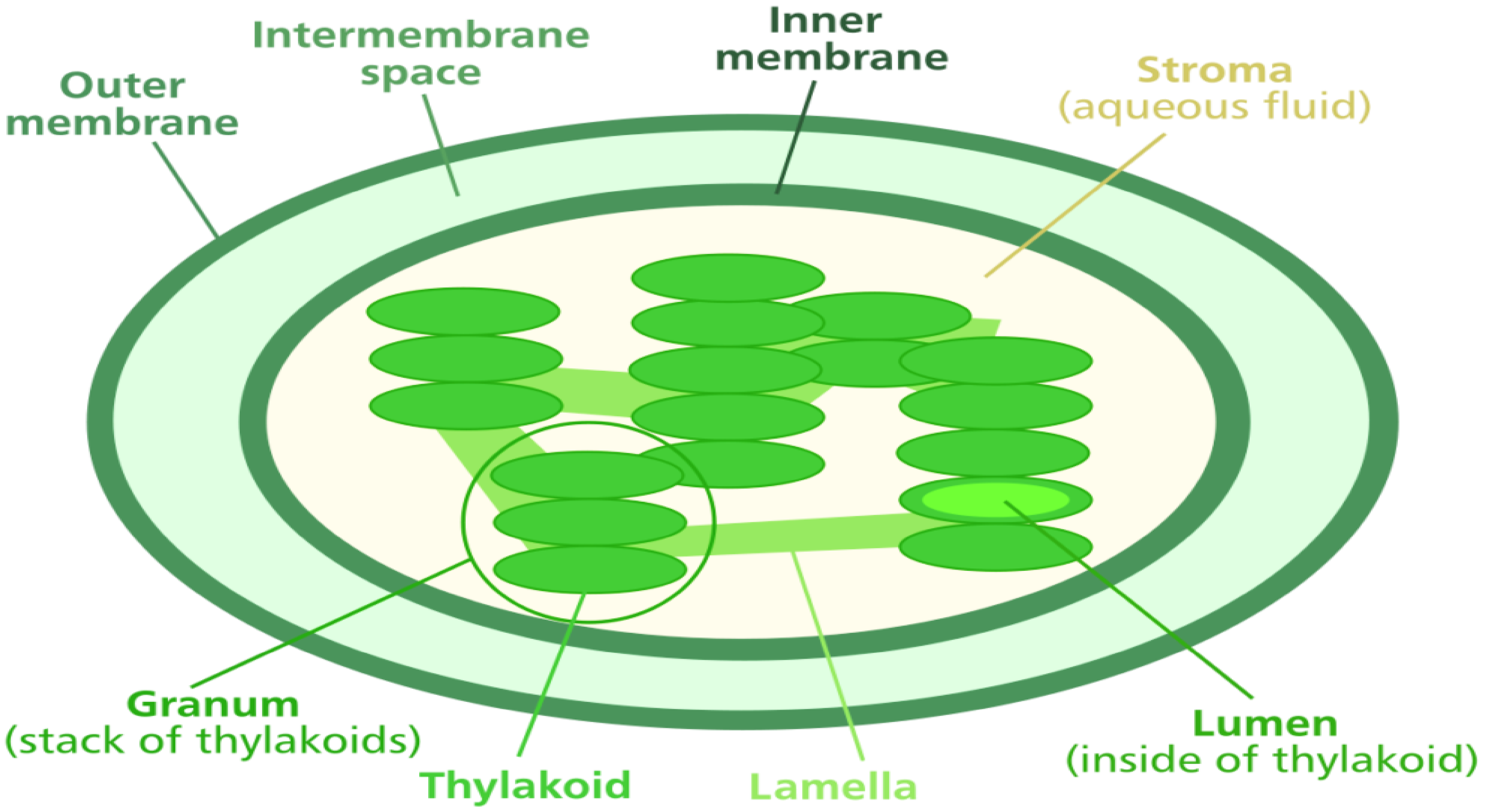
The various plant pigments have the ability to perform all of these aforementioned phenomena. During the process of photosynthesis, we find that chlorophyll molecules lose and return a significant amount of light, while we find that some other pigments such as carotenoids and those associated with chlorophyll absorb light energy and transmit it to chlorophyll. Some compounds during the photosynthesis of carbohydrates



## 5- The chemical composition of chloroplast :

By examining chloroplasts with an electron microscope, it is clear that there is a double outer membrane that contains two types of platelets. The first of which is called the lamellar ***grana*** and contains photosynthetic pigments, and the second of which is called the lamellae ***astroma*** and contains the enzymes of the dark reaction.

It can be indicated that the plastid or part of it is able to carry out the process of photosynthesis, and it can also be indicated that the smallest part of the plastid can carry out the process of photosynthesis. This part must contain at least 400 chlorophyll molecules. This part is called the quantasome or the representative light unit.


Outer membrane
Intermembrane space
Inner membrane
Stroma
(aqueous fluid)
Granum
(stack of thylakoids)
Thylakoid
Lamella
Lumen
(inside of thylakoid)

The process of photosynthesis takes place inside the chloroplast, which is made up of particles surrounded by a double cytoplasmic membrane that contains a fluid known as the stroma, and has sheets called Granum, and each of these sheets is called Grana, containing pigments and enzymes for the process of metabolism.

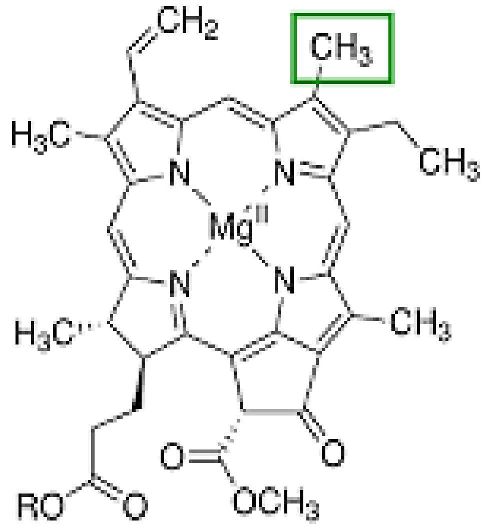
There are 60 grana in each plastic, and the light energy is converted into chemical energy in the grana, as it contains pigments and enzymes for the metabolism process. Oxygen is contained within the grana, while carbon dioxide is reduced in the stroma and carbohydrates are formed.

# 6- Photosynthetic pigments

Pigments are found in the plastids and are responsible for:

**Chlorophyll pigments**

- Chlorophyll is the green pigment in plants, and it is the most important pigment in photosynthesis. To date, eight types of chlorophyll have been identified, the most important of which are chlorophyll (A, B, C, D, and E).
- Of these, only two are found in the chloroplasts of higher plants: chlorophyll a and chlorophyll b. The most important is chlorophyll A, as it is found in plants, algae, and photosynthetic cyanobacteria.
- Chlorophyll (a) gives a yellowish-green colour, chlorophyll (b) is usually bluish-green.
- Chlorophyll dye consists of the element magnesium in the center surrounded by a ring structure of nitrogen (porphyrin ring) linked to a long chain of hydrogen-carbon (vitol chain). There are six main types of it, and the chemical formula for each of them varies according to the type.
- Chlorophyll contains a magnesium ion located in the center of the molecule, and this ion is thought to be necessary to enable this pigment to absorb light.



## 7- The mechanics of photosynthesis

Photosynthesis can be divided into two main parts, which are the light reaction or the Hill reaction, and the second part, known as the Dark reaction (Blackman reaction), and the first is known as the photolysis stage, in which chlorophyll absorbs light energy that encourages the splitting of water into oxygen and hydrogen, with the rise of oxygen, but hydrogen combines with The receptor is NADP.

As a result of chlorophyll's absorption of blue and red light, it loses an electron, so active negative electrons are attracted inside the grana by electronic receptors, and during the transition process, the energy of an electron decreases and the released energy is absorbed by ADP to form ATP.

As for the second reaction, known as the dark reaction, it is a chemical reaction known as the Co2 fixation cycle. This reaction does not need light, and its name does not mean that it takes place in the dark. Rather, it means that light is not necessary to complete it, and in it Co2 is fixed and carbohydrates are formed.

# First: the Hill reaction: the light reaction or the Hill reaction

In 1937, the scientist Robert Hill made an attempt to study the reactions of the photosynthesis process by conducting research on isolated chloroplasts instead of conducting them on whole plants. He found that the isolated chloroplasts were able to produce oxygen, i. It is able to oxidize compounds and become reductive) such as ferrocyanide compounds, ferric potassium oxalate compounds, and chlorinone compounds that reduce to hydroconion, where iron ions turn into ferrous and water is oxidized, i.e. these compounds replace NADP, which is the hydrogen receptor in the photosynthesis process.

When light with a wavelength of 680 millimeters falls on chlorophyll A, which is known as the Pigment system (PSI), the photons of light collide with chlorophyll, and the chlorophyll molecule becomes high-energy. In that high-energy state for a very short period of 9-10 seconds, if the energy is not used, it will dissipate in the form of radiation, and the electron may be held from the chlorophyll molecule.

Chlorophyll in (PSI) is oxidized by losing an electron, so it receives Ferrodoxin dye, which is the dye that accepts the electron and reduces NADP, which is a protein cofactor. And the enzymatic accompaniment known as NADP is reduced in the presence of the enzyme NADP reductase - Ferredoxin, and NADP turns into NAD PH, and the source of hydrogen here is water.

In the absence of the enzyme that carries NADP and the enzyme that reduces it, Ferredoxin dye pushes the current of electrons to receptors, which are, in order, cytochrome b, then cytochrome f, then to the cucontaining plstocyanine protein (PC) and then again to chlorophyll a so that the first chromosome system (PSI) maintains Its reduced image is an electron donor, and in that cycle the electron loses its energy, which gives it to the ADP compound to form the ATP compound by adding phosphorus to ADP in a system known as Cyclic photo photophosphorylation.

# اولا : التفاعل الضوئي او تفاعل هيل Hill reaction :

➢ وفيها يقوم جهاز التخليق الضوئي، بامتصاص الطاقة الضوئية، وبواسطتها يقوم بعملية التحليل الضوئي لجزئ الماء، إلي أيون + H و غاز الأكسجين O2، الذي يتصاعد. ويستعمل الأيدروجين في اختزال عامل مساعد، قد يكون معاون الإنزيم $NADP^+$ . ويتحول الي الصورة المختزلة $NADPH+H^+$ .

$$2NADP^+ + 2H_2O \qquad 2NADPH + H^+ + O^2$$

# ثانيا : تفاعل الظلام او تفاعل بلاكمان Blackman reaction

- مرحلة التفاعل الظلامي( تفاعل بلاكمان): Blackman Reaction

  - وفي هذه المرحلة، يتحد ثانى أكسيد الكربون، مع مركب ما، دون حاجة إلى وجود ضوء ، وان المركب الناتج بعد اتحاد ثانى أكسيد الكربون، يتم اختزاله بواسطة عوامل مساعدة، سبق اختزالها، في التفاعل الضوئي.
  - وعلي ضوء ذلك، يمكن مناقشة عملية التخليق الضوئي من زاويتين: الأولي هي كيفية استخدام الماء كعامل مختزل في التفاعل الضوئي، والثانية: هي كيفية اختزال ثانى أكسيد الكربون، وتحويله في النهاية الي كربوهيدرات.

## تقدير معدل عملية التخليق الضوئي:

- يمكن قياس المعدل أو السرعة التي تجري، بها أي عملية حيوية ، عن طريق تقدير سرعة اختفاء المواد الداخلة في التفاعل، أو ظهور المواد الناتجة عن التفاعل.
- وبتطبيق ذلك في حالة التخليق الضوئي، فإنه يمكن قياس سرعة اختفاء ثانى أكسيد الكربون $CO_2$ ، أو سرعة ظهور الأوكسجين $O_2$ كناتج ثانوى، أو تقدير الكربوهيدرات المتكونة، عن طريق تقدير معدل زيادة المادة الجافة في زمن معين .....ويجب ملاحظة أن هناك عملية أخري.
- تتم في نفس الوقت، في الخلايا التي تقوم بعملية التخليق الضوئي، وهي عملية التنفس هي عملية عكسية للتخليق الضوئي، حيث يتم فيها أكسدة الكربوهيدرات إلي $CO_2$ ، وماء، لتحرير الطاقة اللازمة للنبات

# Factors affecting photosynthesis:

- Carbon dioxide concentration in the air surrounding the leaves
- temperature
- the light

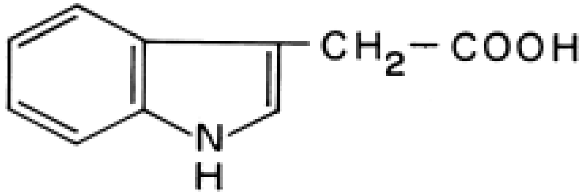
# *The Plant Hormones*
Their Nature, Occurrence, and Functions

- **The Meaning of a Plant Hormone**
- Plant hormones are a group of naturally occurring, organic substances which influence physiological processes at low concentrations. The processes influenced consist mainly of growth, differentiation and development, though other processes, such as stomatal movement, may also be affected. Plant hormones1 have also been referred to as ‘phytohormones’ though this term is infrequently used.
- Phytohormones is define as a substance which is transferred from one part of an organism to another.

- Auxin, the first-identified plant hormone, produces a growth response at a distance from its site of synthesis, and thus fits the definition of a transported chemical messenger. However this was before the full range of what we now consider plant hormones was known. It is now clear that plant hormones do not fulfill the requirements of a hormone in the mammalian sense. The synthesis of plant hormones may be localized (as occurs for animal hormones), but it may also occur in a wide range of tissues, or cells within tissues. While they may be transported and have their action at a distance this is not always the case. At one extreme we find the transport of

- cytokinins from roots to leaves where they prevent senescence and maintain metabolic activity, while at the other extreme the production of the gas ethylene may bring about changes within the same tissue, or within the same cell, where it is synthesized. Thus, transport is not an essential property of a plant hormone
- Plant hormones are a unique set of compounds, with unique metabolism and properties,. Their only universal characteristics are that they are natural compounds in plants with an ability to affect physiological processes at concentrations far below those where either nutrients or vitamins would affect these processes.

- **Types of Plant Hormones**
- There are five general classes of hormones: auxins, cytokinins, gibberellins, ethylene, and abscisic acid.
- Auxins
- An auxin, indole-3-acetic acid (IAA), was the first plant hormone identified. It is manufactured primarily in the shoot tips (in leaf primordia and young leaves), in embryos, and in parts of developing flowers and seeds.




INDOLEACETIC ACID

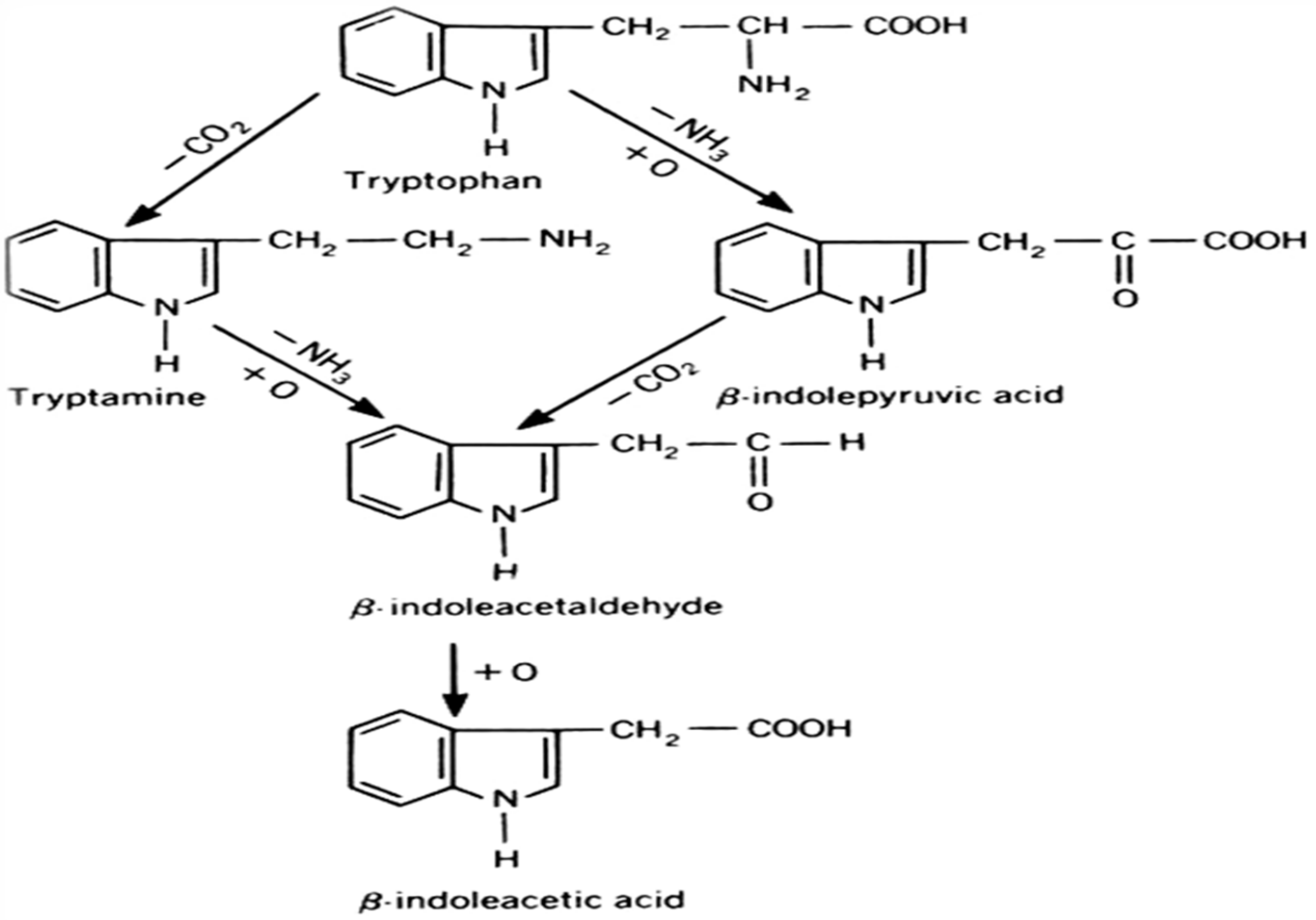
- Sites of biosynthesis
- IAA is synthesized from tryptophan or indole primarily in leaf primordia and young leaves, and in developing seeds.
- Transport
- IAA transport is cell to cell, mainly in the vascular cambium and the procambial strands, but probably also in epidermal cells .Transport to the root probably also involves the phloem.
-

- **Auxins alone or in combination with other hormones are responsible for many aspects of plant growth. IAA in particular:**

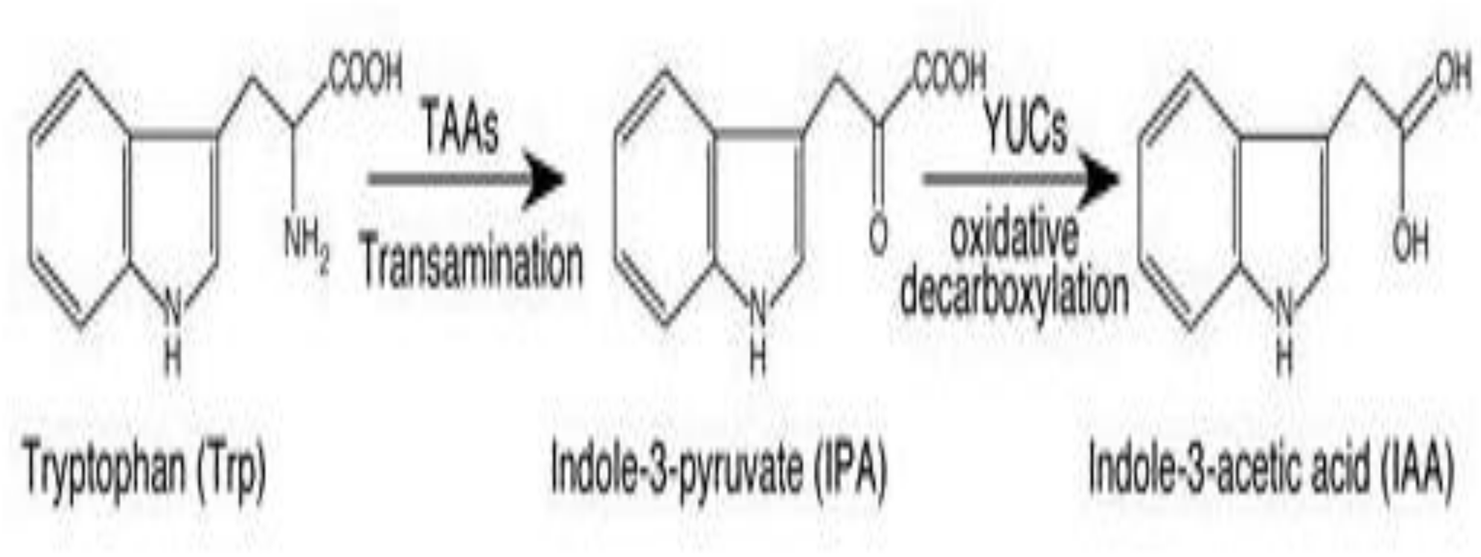
- Activates the differentiation of vascular tissue in the shoot apex and in calluses; initiates division of the vascular cambium in the spring; promotes growth of vascular tissue in healing of wounds.
- Activates cellular elongation by increasing the plasticity of the cell wall.
- Maintains apical dominance indirectly by stimulating the production of ethylene, which directly inhibits lateral bud growth.
- Activates a gene required for making a protein necessary for growth and other genes for the synthesis of wall materials made and secreted by dictyosomes.

- Promotes initiation and growth of adventitious roots in cuttings.
- Promotes the growth of many fruits (from auxin produced by the developing seeds).
- Suppresses the abscission (separation from the plant) of fruits and leaves (lowered production of auxin in the leaf is correlated with formation of the abscission layer).
- Inhibits most flowering
- Activates tropic responses.
- Controls aging and senescence, dormancy of seeds.

• Biosynthesis of indol-3- acetic acid

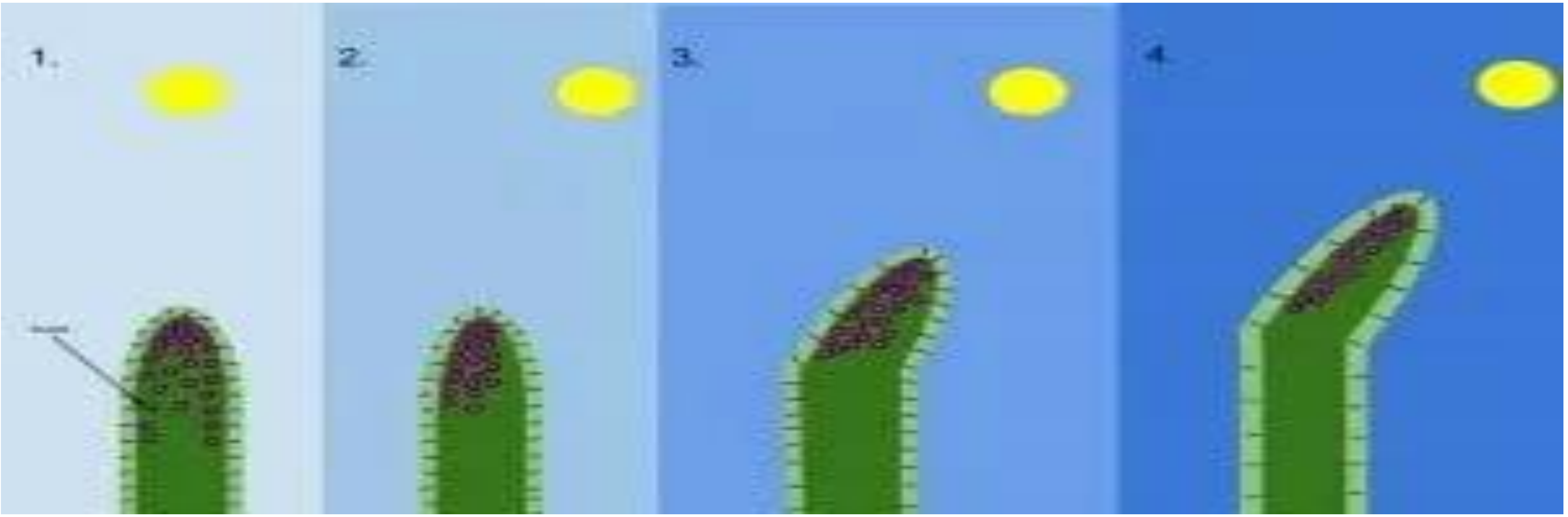


- A complete tryptophan-dependent auxin biosynthesis pathway in plants.
- To create this molecule, two enzymes are needed to act on tryptophan. First, an amino-transferase removes a nitrogen and a hydrogen from the side-chain attached to the 5-sided ring. Then, a decarboxylase enzyme removes the carboxyl group, leaving only COOH. A chloride ion attaches to the six-sided ring, and IAA is born. Most auxins are some derivation of this



- Auxin Function
- The auxin group of hormones has a wide range of uses in a plant. Auxin molecules are found in all tissues in a plant. However, they tend to be concentrated in the meristems, growth centers which are at the forefront of growth. These centers release auxin molecules, which are then distributed towards the roots. In this way, the plant can coordinate its size, and the growth and development of different tissues based on the gradient of the auxin concentration.

- Auxin affects many different cellular processes. At the molecular level, auxin molecules can affect cytoplasmic streaming, the movement of fluids within a cell, and even the activity of various enzymes. This gives auxin direct control over the growth, development, and proliferation of individual cells within the plant. The auxin gradient directly affects processes such as flower initiation, fruit development, and even tuber and bulb formation. Even on a daily basis, auxin levels affect processes such as phototropism, which allows the plant to follow the sun and gain the most energy. The auxin controls this process by concentrating in the side of the plant away from the sun. This causes changes in the cells, which bend the plant toward the light. This can be seen in the image below.


1.
2.
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- Another important feature which auxin gradients provide many plants is apical dominance. Apical dominance is formed when a single meristem is growing faster and more efficiently. Eventually, the auxin released from this meristem inhibits any new shoots from budding off below it. If the stem is cut off, many new shoot will erupt below the stem, as the auxin gradient has been disrupted and the system must create a new leading shoot. The auxin gradient, when established, determines how fast internodes grow, which determines the height of the plant. When discussing the function of the auxin molecules in a plant, it is almost easier to discuss the things they do not control.

- Synthetic Auxin Analogs
- After studying the structure of natural auxin molecules, scientist were easily able to produce molecules which were similar to natural auxins. These synthetic auxin analogs have many applications. They can be used to encourage growth in certain plants. Synthetic auxin treatment is used on many plant cuttings, to induce rooting processes. In this way, scientist can make plant clones by taking cuttings, and growing the cuttings into entire plants.

- 1-Naphthaleneacetic acid (NAA) is a coming rooting chemical, and a synthetic auxin. This fake auxin is marketing to regular gardeners. While there are some safety and handling concerns, fake auxin molecules have been used since the 1940’s to stimulate the growth of cuttings. Scientist also found that auxin molecules could have anti-growth properties as well.

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