Crop Physiology (BOT 121)

Lecture 01 :- Introduction to Crop Physiology and it's importance in Agriculture.

Physiology : Study of life processes.

Growth : Irreversible changes in characteristics of an organism is called **growth.**

Guttation : (i.e. exacudation of droplet through hydathodal cell)

Loss of water i.e. exacudation of droplet in the form of liquid from leaf margin.

Transpiration : (By stomatal cell)

Loss of water in the form of vapours.

Bleeding : Removal of liquid from cut portion of plant is called **bleeding**.

Cell : Cell is defined as the **structural and functional unit of life**.

Lipids : (Plastids)

- **Chloroplast :** Use for photosynthesis.
- **Chromoplast :** Use for coloring.
- **Leucoplast :** Storage of food; colourless plastids; storage of proteins, fats and carbohydrates.
- **CAMP : Crassulacean Acid Metabolism Process** is use for open stomata during night and closed in day to prevent water loss.
- **Note :** But in the presence of sunlight **Chromoplast + Leucoplast** converted into **Chloroplast.**

Ascent of Sap : The upward movement of water and dissolved salt is known as **ascent of sap.**

Crop : Aggregation of plants grown in unit area of land for economic purpose is called as **crop.**

Physiology : The science that deals with concerned life process of living organisms is called as **physiology**.

Crop Physiology : The branch of science which deals with the study of life processes of plants/crops is known as **crop physiology**.

Importance of Crop Physiology in Agriculture :

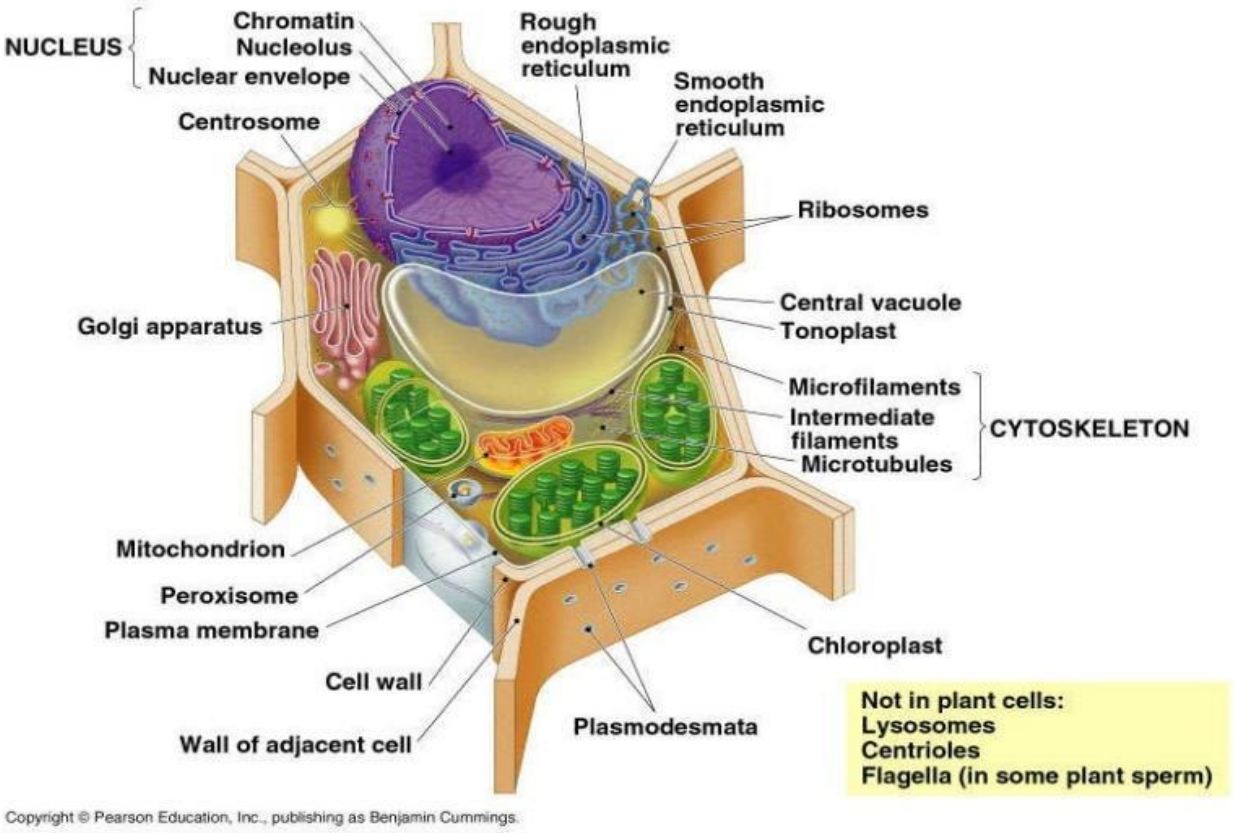
- ✓ The knowledge of plant physiology helps **to study agricultural, horticultural, forestry and several other basic botany branch**.
- ✓ **Plant Metabolic Process** are responsible to increase in crop production.

- ✓ The knowledge of crop physiology play an important role in production of new varieties and strains.
- ✓ The basic knowledge of crop physiology **can help in the increase of photosynthetic conversion of solar energy in the production of food material.**
- ✓ The basic knowledge of **atmospheric nitrogen fixation helps in increase utilization of atmospheric nitrogen by different plant species.**
- ✓ The detail knowledge of **plant hormones facilitates growth and development of crop.**
- ✓ The study of plant physiology is important in agriculture **to evaluate drought and stress.**
- ✓ It helps to **evaluate nutritive values of cereals, pulses, oilseed, poultry and cattle field.**
- ✓ The Seed Physiology gives us an idea about the **structure of seed and maturity of different agricultural crops.**

Lecture 02 :- Plant Cell – structure, cell organelles and their role.

Plant Cell :

- ✓ The **structural** and **functional** unit of plant is known as **plant cell** and plant cell discovered by **Robert Hooke**.



There are various structures seen in plant cells are :

- ✓ Cell Wall
- ✓ Plasma Lemma
- ✓ Cytoplasm
- ✓ Endoplasmic Reticulum
- ✓ Ribosomes
- ✓ Golgi Bodies
- ✓ Lysosomes
- ✓ Spherosomes
- ✓ Chloroplasts
- ✓ Mitochondria
- ✓ Nucleus

Cell Wall :

- ✓ Plant cell is enclosed by **semi-rigid laminated external non-living covering** known as **cell wall**.

Functions of Cell Wall :

- ✓ It serves for the **mechanical suppor**t and **maintenance of a definite form of organism.**
- ✓ It is **absent** in **animal cell** which has only plasma membrane as **outermost layer.**
- ✓ The cell wall is secreted by the **living portion (protoplasm)** of the plant cell and made up of **primary cellulose (polysaccharides) , complex carbohydrate material.**
- ✓ It consists of three layers i.e. **primary cell wall (thin in size), secondary cell wall (thick in size) and middle lamella.**
- ✓ The middle lamella is common layer of the **two adjacent cells** and it consist of **calcium and magnesium peptate.**
- ✓ Primary cell walls are typically **thin** while secondary cell wall is **thicker and stronger** than the primary cell wall.
- ✓ Primary cell wall is **characteristic of young growing cell.**

Plasma Lemma/Plasma Membrane :

- ✓ The cells are bounded by **thin membrane** which is not **visible under light microscope** is called as **plasma lemma or plasma membrane.**
- ✓ It is made up of **lipoprotein and polysaccharides** in addition to these compound sometimes **small amount of ions like Ca, Zn, Mg** are also present in the **biomembrane.**
- ✓ Plasma membrane is **semi-permeable, selectively permeable, differentially permeable.**
- ✓ The cell membrane regulates **in and outward movement** of substances in response to concentration gradient or it may be an active process against concentration gradient.

- ✓ In a living cell substance move selectively through the membrane once this membrane is removed, damage or ruptured the substance move **inward and outward freely.**
- ✓ There may be **state of equilibrium** achieved which living state is **rare**.

Cytoplasm :

- ✓ Cytoplasm is part of protoplasm which lies outside the nucleus and inner to the cell wall.
- ✓ Plasma lemma or plasma membrane is present outside the cytoplasm.
- ✓ The part of cytoplasm made up of **Endoplasmic Reticulum** and **Cytoplasmic Matrix** is known as **Endoplasma.**
- ✓ The cytoplasmic matrix contains **several protoplasmic bodies** called **Organelles/Cell Organelles.**
- ✓ These organelles have **definite morphology, specific functions** and **distinctive chemical composition**.
- ✓ Some cell organelles are **double membrane (e.g. nucleus, plastids, mitochondria)** and some are **single membrane (e.g. dictosomes, microbodies)** on the other hand **ribosomes lack membrane.**

Endoplasmic Reticulum :

- ✓ The cytoplasm of **meristematic cell is interlaced by a network of membrane bound vesicular system** called as **cytoplasmic reticulum or endoplasmic reticulum.**
- ✓ The membrane bounding this system have a **lipoprotein structure.**
- ✓ ER form **storage** and **conducting system** and is concerned with the **storage secretion** and **transport of protein** synthesized by cell to the exterior for the extra cellular use.
- ✓ It is also concerned with **lipid metabolism**, their storage in the **plastids** and their export from the cell thus it acts as a **intracellular** and **intracellular** channel system of the **transport of metabolites** within the cell and from the cell.
- ✓ ER is grouped into two categories : **Smooth ER** and **Rough ER**.

Ribosomes :

- ✓ Such microscopic particles associated with ER and floating free in the cytoplasm called as **Ribosomes/Microsomes.**
- ✓ Microsomal fractions of cytoplasm contains **40-50 %** of cell RNA, **15 %** of cell protein and about **50 %** of cell photo-lipids.
- ✓ Hence, Ribosomes have an important role in **protein synthesis.**
- ✓ Ribosomes occur in cytoplasm in groups of **two, three, four, five** Ribosomes.
- ✓ These groups have been called **Polyribosomes, Polysomes, Ergasomes , Ribosomal Cluster.**

Lysosomes :

- ✓ The light fraction after centrifugation which contain **high level of hydroylases enzyme.**
- ✓ This enzymes contain in a special organelles called **Lysosomes** and were suppose to bring about **degradation of several biological substrates**
- ✓ Lysosomes are also called as **"Suicidal Bags".**

Spherosomes :

- ✓ Certain tiny vesicles should **expand** and **developed** into bodies called **Spherosomes.**
- ✓ Spherosomes are **abundant** in cells and reach in **fats,** these indicates the **ER** in active in **production of fats.**

Peroxisomes and Glyoxisomes :

- ✓ These are **spherical organelles** which were refer to as **microbodies** in the plant.
- ✓ Peroxisomes have been **universally identified** in plant and animal species.
- ✓ Peroxisomes check the formation of **toxic hydrogen peroxide** in the cell cytoplasm.

Plastids :

- ✓ There are three plastids in plant cell i.e. **chloroplastids, chromoplastids and leucoplastids.**
- ✓ Different kinds of plastids occur in plant cell.
- ✓ They are **complex microscopic organelles** which are divisible on the basis of **colouration and functions.**
- ✓ Chromoplasts are variously **pigmented** and may not contain **chlorophyll** but they consist of **different coloring pigments** other than **chlorophyll.**
- ✓ Leucoplasts are class of plastid do not contain **any visible content** and are chiefly concerned with the **synthesis** and **storage of various types of carbohydrates.**
- ✓ In comparison to **Leucoplast and Chromoplast, Chloroplasts are more important plastids in plant cell** because they consist of **chlorophyll pigment (green pigment).**
- ✓ Chlorophyll is a **essential pigment** of photosynthesis that's why this plastids is called as **Photosynthetically Active Plastids (PAP).**
- ✓ When Leucoplasts and Chromoplasts receives the **photons of light** they may convert into **chloroplast** and become **photosynthetically active.**

Mitochondria :

- ✓ Mitochondria is called as **"Powerhouse of the Cell"** lying in the cytoplasm.
- ✓ Mitochondria provides the cell with most of its usable energy in the form of **ATP (Adinosine Tri-Phosphate) Energy** rich compound which is synthesized in them during the respiratory oxidation of **food material** such as **proteins, fats and carbohydrates, etc.**

- ✓ The Mitochondria form ATP is dispersed throughout the cell and energy stored in it is readily released and utilized to drive energy consuming in the cell.

Nucleus :

- ✓ Nucleus is discovered by **Robert Brown** in **1831.** It has controlling influence on **heredity and the physiological activity of the cell.**
- ✓ It controls/direct the sun of the enzymes that catalyze most of the metabolic reactions of the cell, three structures **(chromosomes, ribosomes, nucleolus)** are embedded in the **nucleoplasm.**
- ✓ Chemical analysis of the nucleoplasm shows that **large amount of lipids, phospho-lipids and particularly proteins** chemically it consists of **RNA, DNA** and **Protein.**

Permeability :

- ✓ Permeability is defined as the **ability of protoplasm to allow diffusion dissolved substances through it.**

Diffusion :

- ✓ The diffusion is defined as the **movement of molecules of particles from a region of higher concentration to the region of lower concentration.**
- ✓ This process broad about by the **kinetic energy of the molecules.**
- ✓ Some substances pass **in/out of cells by simple physical diffusion.**
- ✓ All molecules in liquid and gases **10** to move in all directions, until they are spread evenly throughout the available space.

Osmosis :

- ✓ Osmosis is as **special kind of diffusion of water molecules across a differentiable permeable membrane from a region of lower concentration to region of higher concentration.**
- ✓ Cell membrane **selectively reticulate the passage of most solutes, but water is able to move rather freely in and out of the cell.**

Significance of Osmosis :

- ✓ It helps in **water absorption in plants.**
- ✓ The turgidity of plant organs **depend on the water** which is absorbed due to osmosis.
- ✓ It helps in **movement of water from one cell to another.**
- ✓ It also maintains the **resistance of plants during drought and frost.**
- ✓ It helps in **opening and closing of stomata.**
- ✓ The expansion of cells is dependent upon **turgidity.**

Lecture 03 & 04 : Absorption of water and path of water, Ascent of Sap and Theories of Ascent of Sap.

Introduction :

- ✓ Water releases through **transpiration, guttation and bleeding.**
- ✓ **Transpiration : Stomatal Transpiration, Cuticular Transpiration, Lenticular Transpiration.**
- ✓ Only **3 %** of water is used for **vital process** of plant.
- ✓ **97 %** of water is **loss** in plant.

Water Movement in Plants :

- ✓ A continuous string is maintained when water flows from the soil to the stem and then to the leaves finally leaving the plant system to the stomata into the atmosphere.
- ✓ These are mainly three steps discussing water movement regarding plant : **Water Absorption, Water Transportation and Water Release.**

Water Absorption :

- ✓ While discussing water flow in the land plants, roots play an important role in **extracting water** from the soil and conducted to other parts to the **xylem.**
- ✓ Before reaching **xylem tissue,** water has to cross the **epidermis, cortex and then endodermis.**
- ✓ Water may easily travels the **single cell layer of epidermis to reach the cortex** which comprises **5 to 10 cell layers** and the cytoplasm of adjacent cells being **continuous** because of **plasmodesmata.**
- ✓ The collective protoplasm of the interconnected cells referred to as **simplasm.**
- ✓ In the simplasm, **diffusion occurs from cell to cell** which facilitate **the movement of water and solutes** in this pathway across the **cortex** by the process of **diffusion** water moves from **cell to another cell** through **plasmodesmata.**

Water Transportation : (Ascent of Sap)

- ✓ Upward movement of water from the **root zone to the stem and leaves to the aerial parts of the plant** is called as **ascent of sap.**
- ✓ Plants absorbs water through the **roots and leaves**.
- ✓ The water moves from the **bottom to the tip portion of the plant body** against the **force of gravity.**

Water Release :

- ✓ Water is released from the plant by different processes namely **transpiration, guttation and bleeding.**
- ✓ Transpiration is a **continuous process.**
- ✓ Guttation is a **discontinuous process.**

Theories of Ascent of Sap :

1) **Theory of Westermair : (1883-1884)**
   - ✓ He suggest that **trackery elements held in water** and due to this **water is absorbed by the plant roots.**
2) **Bose Pulsation Theory : (1923)**
   - ✓ According to Bose, **water continued to rise in the absence of root pressure and transpiration.**
   - ✓ Ascent of Sap is due to the **pulsatory activity of the innermost layer of the cortex.**
3) **Godlewaskis Theory : (1884)**
   - ✓ According to him, the upward movement of water was due to **pumping activity** of the cell of wood parenchyma.
4) **Root Pressure Theory :**
   - ✓ According to this theory, **upward movement of water takes place due to the pressure exerted by the plant roots.**
5) **Imbition Theory :**
   - ✓ According to this theory, **water goes upward by the force of imbition.**
6) **Transpiration Pulled Theory :**
   - ✓ According to this theory, Evaporation from the surface of parenchyma cells creates some **tension** and **due to this water rises from the bottom to the tip portion of the plant.**

Lecture 05 :- Transpiration – Definition, types, structure of stomata, physiology of stomata, factors affecting transpiration, Water Use Efficiency (WUE) & factors affecting W.U.E..

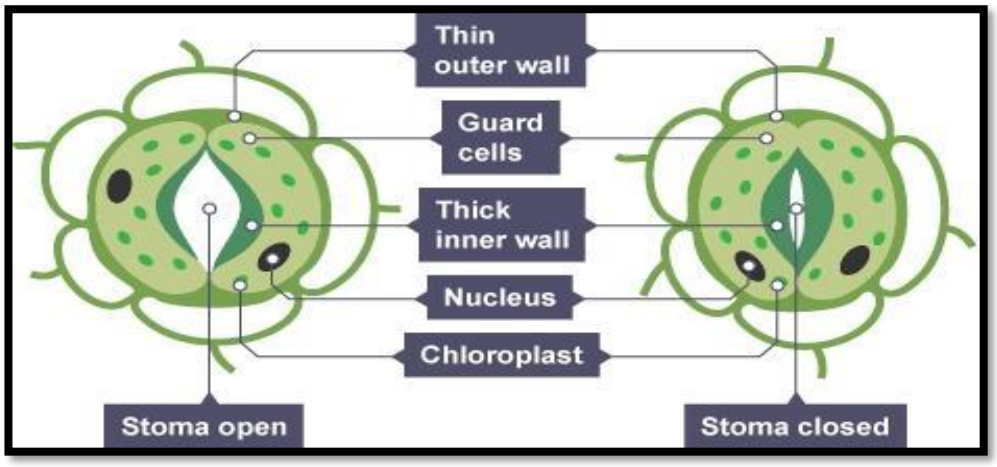
Transpiration : The **loss of water in the form of vapours from the aerial part of the plant i**s known as **transpiration.**

Types of Transpiration :

On the basis of loss of water, transpiration is categorized as follows :

1) **Stomata Transpiration : 80-90 %** water loss through **stomata**.
2) **Cuticular Transpiration : 8-10 %** water loss through the **cuticle of the leaves and young stem.**
3) **Lenticular Transpiration : 0.1 %** loss of water through the **lenticells of fruits** and **woody stem**.

Structure of Stomata :



✓ The epidermal surface of a leaf has tiny pores called **stomata.**

✓ Stomata which are **microscopic** and are surrounded by **two guard cells.**

- ✓ That two guard cells controlled the **opening and closing of stomata.**
- ✓ Cell wall of guard cells adjacent to the **stomatal pore is thicker** and more in **elastic** than the wall adjacent to the surrounding epidermal cells.
- ✓ The guard cells contained **chloroplast,** while the **inelastic thicker part of the wall** encloses the pores, **stomata** occur on the both the surfaces of leaf but are more frequent on the lower surface of the leaf.
- ✓ In Water Lily, stomata are **present only the upper surface of leaf.**
- ✓ Stomata are **absent** or **function less** in submerged water plants.
- ✓ When stomata doesn't receives water.
- ✓ When stomata receives water.

Stomatal Frequency : The **number of stomata per unit area of leaf** is known as **stomatal frequency.**

Stomatal Index : Stomatal Index is defined as the percentage number of stomata as composed with all the epidermal cells in an unit area of leaf. It is denoted by **"R".**

Classification of Stomata :

- ✓ There are mainly two types of stomata depending upon the morphology of guard cell : **Dumbbell Shape Stomata** and **Kidney Shape Stomata.**

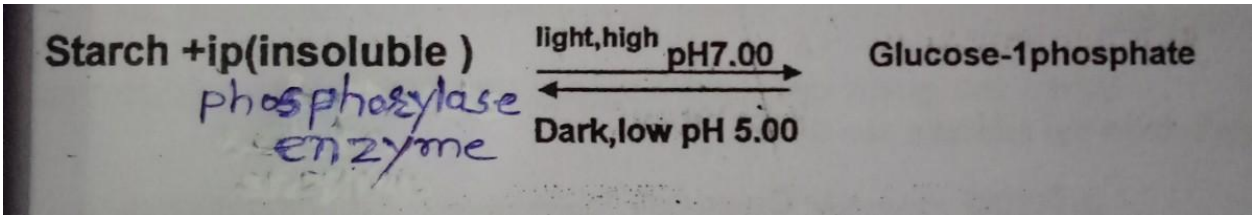
Dumbbell Shape Stomata :

- ✓ In grasses, the guard cells have characteristics dumbbell shape with bulbous ends.
- ✓ The pore proper is long slit located between the two handles of dumbbells.
- ✓ These guard cells are always flanked by a pair of differentiated epidermal cells called **subsidiary cells.**
- ✓ The guard cell, subsidiary cell and pore are connectively called as **stomatal complex.**

Kidney Shape Stomata :

- ✓ In dicots and non-grass monocots, guard cells have an **elliptical (often called kidney shaped)** with the pore at the center.

Mechanism of Opening and Closing of Stomata : (Movement of Stomata)



- ✓ An increase in **turger pressure** will cause the more elastic part of guard cell wall to **stretch considerably and stomata open.**
- ✓ When the water is **loss** the guard cells **decrease in volume**, the walls are **straighten and aparture is closed.**
- ✓ Usually stomata remain **open during day time** and **close at night time.**
- ✓ However, In many succulents stomata **remain open even at night.**
- ✓ Stomata can also **open in response to high temperature** and **high pH i.e. 7 pH** and low levels of CO_2 which are reverse of the above mentioned once that means **when temperature is low, pH is low and CO_2 is increases then the stomata remains close.**
- ✓ **When temperature is high, pH is high and CO_2 is decreases then the stomata remains open.**
- ✓ **Increase osmotic potential** cause and increase in the **turgidity of guard cells.**
- ✓ As a result, the volume of guard cells **increase and guard cells bulge out.**

- ✓ Consequently the pore is **open.**
- ✓ Several **phytoharmones (plant hormones)** and **phenolic compound** affect the stomatal **opening and closing.**
- ✓ **Cytokinins, Cyclic AMP (Adinosine Monophosphate)** promotes stomatal opening while **abscisic acid** and **salicylic acid** reduce stomatal aparture.

Factors affecting Transpiration :

- **External Factors :**
  1) Atmospheric Humidity
  2) Light
  3) Temperature
  4) Wind
  5) Atmospheric Pressure
  6) Available Soil Water
  7) CO_2 Content
- **Internal Factors :**
  1) Internal Water Condition
  2) Structural features
  3) No. of Stomata /Structure of Stomata

- ✓ The **greater relative humidity** of the atmosphere, the **slower** the rate of transpiration.
- ✓ **Light** regulates the physiology of a guard cells for **opening and closing of stomata,** it **increase** the rate of transpiration.
- ✓ **Increase in temperature** enhance the rate of transpiration.
- ✓ **Wind Velocity** also increase the rate of transpiration.
- ✓ As a **low atmospheric pressure** increase the rate of transpiration.
- ✓ The rate of transpiration directly depends upon **availability of water in soil.**
- ✓ High Concentration of CO_2 in atmosphere causes **stomatal closure** which result in **reduction in transpiration rate.**

Mechanism of Water Absorption :

- ✓ The uptake of water by plants is called **water absorption.**
- ✓ Water is absorbed from the soil mainly through **root hairs.**
- ✓ **Kramer (1949)** proposed that water is absorbed by two mechanism. They are : **Active Absorption** and **Passive Absorption.**

Active Absorption :

- ✓ When the roots absorb water by their **own efforts** is called **active absorption.**
- ✓ It takes place when **transpiration is low** and the quantity of water in the soil is **high.**

- ✓ In this process the root cells play **active role in the absorption of water.**

Passive Absorption :

- ✓ It takes place mainly due to **transpiration.**
- ✓ In passive absorption, the roots remain **inactive** and **the water absorbing forces are first produced in the cells of leaves.**
- ✓ Passive absorption of water takes place, when rate of transpiration is **high.**
- ✓ **Rapid Evaporation** of water from the leaves during transpiration creates a tension in water in the **xylem of the leaves.**

Difference Between Active and Passive Absorption :

S. R.	Active Water Absorption	Passive Water Absorption
1.	Active absorption of water occurs due to activity of **roots and particularly root hairs.**	Passive absorption of water occurs due to the activity of **upper part of plant, such as shoot & leaves.**
2.	It requires **energy or ATP.**	It does **not require energy.**
3.	Active absorption creates **root pressure.**	Pass absorption **does not creates root pressure.**
4.	The movement of water takes place from **the solution of higher concentration to the solution of lower concentration i.e. against the concentration gradient.**	The movement of water takes place from **the solution of lower concentration to the solution of higher concentration i.e. according to osmotic gradient**.
5.	The absorption of water occurs by the **osmotic and non-osmotic processes.**	The water is absorbed due to **active transpiration in aerial parts.**
6.	In the movement of water, **living part of protoplast is involved.**	The movement of water is through **free spaces or apoplast of root** and it may include **cell wall and intracellular spaces.**
7.	Evidences in support of active water absorption are **root pressure, bleeding and guttation.**	Evidences in support of passive water absorption can be given by **cutting the roots under water.**

Difference Between Transpiration and Guttation :

S. R.	Transpiration	Guttation
1	The loss of water in the form of vapour from the aerial parts of plant is called as transpiration.	The loss of water in the form of liquid drop from the uninjured margin of the leaves is called as guttation.
2	It occurs through stomata, cuticle or lenticells.	It occurs through hydathodes.
3	It usually occur during day time.	It usually occur during night time.
4	Water vapours are pure and free of dissolved substances.	Guttation water has many dissolved substances.
5	It is a controlled phenomenon.	It is a uncontrolled phenomenon.
6	Universal phenomenon and occur in plant.	It occurs only in some plants like grasses.
7	It's lower than the temperature of surface.	It's lack such relationship.
8	The stomata of leaves become closed, open or closed according to the need usually they remain open during day and closed during night.	The hydathodes remain open whole day and night.
9	It is controlled by the guard cell.	It is not controlled by the cell.

Water Use Efficiency (W.U.E.) :

- ✓ Water use efficiency can be defined as **the ratio of water used in plant metabolism to water lost by the plant through transpiration.**
- ✓ **97 %** of water is S loss from plant.
- ✓ **2 %** of water is used for **growth and development of plant.**
- ✓ **1 %** of water is used by **plants (biomass).**

$$WUE = \frac{\text{Water used for metabolic process}}{\text{Transpiration}}$$

CHANDRASHEKHAR YELLE

Photosynthetic Water Use Efficiency :

- ✓ Photosynthetic water use efficiency defined as **the ratio of the rate of carbon assimilation (photosynthesis) to the rate of transpiration.**

$$WUE = \frac{\text{Rate of Carbon Assimilation}}{\text{Rate of Transpiration}}$$

Water Use Efficiency of Productivity :

- ✓ Water use efficiency of productivity **as the ratio of biomass / yield produced to the rate of transpiration.**

$$WUE = \frac{\text{Rate of Biomass Production}}{\text{Rate of Transpiration}}$$

Factors Affecting W.U.E. :

- ✓ Soil Texture
- ✓ Seepage
- ✓ Percolation
- ✓ Transpiration
- ✓ Evapotranspiration

<u>Lecture 06 :- Mineral Nutrition of plants, Classification of mineral element, criteria of essentiality, General & Specific role of mineral element and deficiency symptoms, Mechanism of mineral uptake.</u>

Mineral Nutrition :

- ✓ The chemical form in which elements are applied to plants is called as **nutrients.**
- ✓ Mineral nutrients are elements such as **N, P, K** and that plants acquire primarily in the form of **inorganic ions from the soil.**
- ✓ The study of plants **how obtain and use of mineral nutrients** is called as **Mineral** Nutrition.
- ✓ Chemical analysis of plant has shown that plant contain **40 different elements.**
- ✓ Out of these **40 elements,** some are **indispensable/essential** for the normal growth and development of plant that's why, the elements are called as **Essential Elements of Crops/Plants.**
- ✓ This essential elements see classified into two categories according to quantity required by plants :
    - **a) Macro Elements / Major Elements**

b) Micro Elements / Minor Elements

Macro Elements : The essential elements which are required by the plants in **comparatively large amount** called **macro elements. E.g. C, H, O, N, P, K, Ca, Mg, S, etc.**

Micro Elements : The essential elements which required in **very small amount by plants** are called as **micro elements. E.g. Fe, Mn, Zn, B, Ni, Cl, Cu, Mo, etc.**

Classification of Plant Mineral Nutrients According to Biochemical Functions :

For the purpose of discussion and easy understanding mineral nutrients are classified into **4 groups** according to biochemical functions.

Group 1 :- Nutrients that **are part of carbon compound.**

a) **Nitrogen (N) :** Constituent of **amino acid, amides, proteins, nucleic acid, nucleotides, etc.**
b) **Sulphur (S) :** Component of **cystine, custom, methionine, thymine, etc.**

Group 2 :- Nutrients are important in **energy storage.**

a) **Phosphorous (P) :** Component of **sugar phosphate nucleic acid (RNA & DNA), nucleotides, phospho-lipids.**
b) **Boron (B) :** Complexes with **mannan, mannitol, polymanuronic acid.**

Group 3 :- Nutrients that remain in **ionic form.**

a) **Potassium (K) :** Required as a **cofactor for more than 40 enzymes.**
b) **Calcium (Ca) :** Constituent of **middle lamella of a cell wall** required as a cofactor by some enzymes.
c) **Magnesium (Mg) :** Required by many enzymes involved in phosphate transfer constituent of **chlorophyll molecule.**
d) **Chlorine (Cl) :** Required for **photosynthetic reaction** involved in O_2 evolution.
e) **Manganese (Mn) :** Required for activity of some **dehydrogenases, carboxylases, kinases, peroxidases, oxidises.**

Group 4 :- Nutrients that are involved in **redox reaction.**

a) **Ferrous (Fe) :** Constituent of **cytochrome and non-hemi iron proteins.**
b) **Zinc (Zn) :** Constituent of **alcohol dehydrolases, grutamic-dehydrogenases, etc.**
c) **Copper (Cu) :** Component of **Ascorbic acid, Oxidises, Uricase, etc.**
d) **Nickel (Ni) :** Constituent of **urease, nitrogen fixing bacteria.**
e) **Molybdenum (Mo) :** Constituent of **nitrogenase, nitrate reductase, etc.**

Role and Deficiency Symptoms of Mineral Elements :

Carbon, Hydrogen and Oxygen are the elements which can be supplied by the air, water or soil, but remaining all the elements should be supplied to the crops for their better growth and development.

Nitrogen (N) :

- ✓ Nitrogen is essential component of **protein, protoplasm, enzymes and also chlorophyll.**
- ✓ It is also constituent of **purine, porphyrins, coenzymes.**

Deficiency Symptoms :

- ✓ Yellowing of leaves due to **loss of chlorophyll.**

Phosphorous (P) :

- ✓ Phosphorous is an important constituent of every living cell and enters into the composition of **phospho-lipids, nucleic acids, nucleoproteins, coenzymes LIKE NAD, NADP, ATP.**

Deficiency Symptoms :

- ✓ Plants are **stunted** but are often **dark green in colour.**
- ✓ The petioles of leaves and fruits develop **narcotic areas.**

Potassium (K) :

- ✓ Potassium occurs mainly in **soluble inorganic salt or salt of organic acid** in the cells and each **highly mobile** in plants.

Deficiency Symptoms :

- ✓ Results in **weakening of leaves, chlorosis, rolling of leaves, stunted growth** and **shortening of internodes.**

Calcium (Ca) :

- ✓ Calcium is a constituent of **middle lamella** and occurs as **calcium peptate** helps to **cement the wall of the cell.**

Deficiency Symptoms :

- ✓ Leads to the **death of meristematic region.**
- ✓ **Chlorosis** occurs along the margin of young leaves becoming **narcotic.**

Magnesium (Mg) :

- ✓ It plays an important role in **photosynthesis** and **carbohydrate metabolism.**
- ✓ It is a constituent of **chlorophyll molecule** present in the **interveinal chlorosis of the old leaves.**

Deficiency Symptoms :

- ✓ Causes **interveinal chlorosis** first in the **old leaves** and then in **young leaves.**

Sulphur (S) :

- ✓ Sulphur helps in the **formation of amino acids**, such as **cystine and methionine.**
- ✓ It is also essential for the **synthesis of sulphur** bearing vitamins like **biotine, thymine and coenzymes.**

Deficiency Symptoms :

- ✓ The plants deficient in sulphur show **chlorosis of the young leaves first.**
- ✓ Severe deficiency results in **chlorosis of all the leaves** since sulphur is **immobile in the plants.**

Iron (Fe) :

- ✓ Iron is not constituent of **chlorophyll,** but is important for its **synthesis.**
- ✓ It is a component of **metalloflavoproteins and** component of **iron porphyrin proteins.**

Deficiency Symptoms :

- ✓ Iron deficient in the plant **exhibit the interveinal chlorosis of the leaves.**

Manganese (Mn) :

- ✓ Manganese is an **activator of enzymes** involved in **respiration** and **nitrogen metabolism.**

Deficiency Symptoms :

- ✓ Cause **chlorotic and narcotic** cause appears in the **interveinal areas** and on **younger** and **older leaves.**

Copper (Cu) :

- ✓ Copper is required in **very low concentration** or it is a **highly toxic** to plant in a **high concentration.**
- ✓ It is a constituent of **plastocyanin, polyphenol oxidase, ascorbic acid, oxidase and nitrate reductase.**

Deficiency Symptoms :

- ✓ Deficiency causes **macrosis of the tip and margin of young leaves.**

Zinc (Zn) :

- ✓ The presence of zinc in the **traces** is essential for the **normal metabolism of plant.**
- ✓ It is involved in the **synthesis of auxin hormones.**

Deficiency Symptoms :

- ✓ Interveinal chlorosis of the **old leaves starts at the tip and margin.**

Boron (B) :

- ✓ Boron is essential for **translocation of carbohydrates in plants.**

Deficiency Symptoms :

- ✓ Deficiency cause **dead of shoot** and **root tip,** leaves develop **thick coppry texture,** sometimes become **curled and brittle.**

Molybdenum (Mo) :

- ✓ Molybdenum functions as an **activator of the enzyme nitrate reductase** which convert **nitrate** to **nitrite and ammonium ions.**

Deficiency Symptoms :

- ✓ Deficiency cause **interveinal chlorosis of lower leaves.**

Chlorine (Cl) :

- ✓ It is essential for the **growth of tomato.**

Deficiency Symptoms :

- ✓ Deficiency causes **stunted root formation, Inhibition of photosynthesis.**

Mechanism of Mineral Elements Uptake :

- ✓ The mineral uptake is the process in which **minerals enter the cellular material, typically following the same pathway as water.**
- ✓ The most normal entrance portal for mineral uptake is through **plant roots.**
- ✓ During transport throughout a plant, minerals can be exist **xylem** and **enter cells**.
- ✓ Mineral ions cross **plasma membrane by chemiosmotic mechanism.**
- ✓ Plants absorb minerals in **ionic form e.g. nitrate, phosphate, potassium ions.**
- ✓ There all the ions have different difficulty level cross the **charged plasma membrane.**

- ✓ The apparent nutrient occurs by the plant cells through different methods : **Passive Absorption** and **Active Absorption.**

Passive Absorption :

- ✓ It is the **absorption of mineral without direct expenditure of metabolic energy.**
- ✓ In passive absorption, mineral salt absorption is not affected by **temperature and metabolic inhibitors.**
- ✓ Rapid uptake of ions **when plant tissues are transfer from medium low concentration to high concentration.**
- ✓ The major hypothesis that explain passive transport of ions are :
  - **a)** Mass blow theory
  - **b)** Contact exchange theory
  - **c)** Carbonic acid exchange theory
  - **d)** Donna Equilibrium

Active Absorption :

- ✓ The active transport of ions from the **outer space to the cell to the inner space is generally occurs against the concentration gradient enhance to require metabolic energy.**
- ✓ This energy is obtained from **metabolism of cell** either **directly** or **indirectly**.
- ✓ The major hypothesis that explain the mechanism of active transport of ions are :
  - **a)** Carrier concept.
  - b) Cytochrome pump

Ion Accumulation :

- ✓ The penetration of ions of mineral salts into the cells continues even if the concentration of ions inside is more than in the external solution, this phenomenon is called **accumulation.**

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Lecture 07-08 :- Photosynthesis : Definition, Pigments involved, Structure of chloroplast, Light reaction – Photolysis of water, Emerson effect, Cyclic and Non-Cyclic electron transfer, Significance of Light Reaction.

Photosynthesis :

- ✓ Photosynthesis is an intracellular anabolic process in which glucose is synthesized from simple inorganic materials like and water in the presence of light and chlorophyll with the evolution oxygen as by-product.
- ✓ Life on the earth ultimately depends on energy derived from the sun.
- ✓ Photosynthesis is the only process of biological importance that can harvest these energy, the term photosynthesis using of light.
- ✓ Photosynthetic organisms use solar energy to synthesized the complex carbon compound.
- ✓ More specifically light energy drive the synthesis of carbohydrates and generation of oxygen from CO_2 and H_2O.
- ✓ During a process of photosynthesis, **light is converted into chemical energy** and is stored in the organic matter which is usually the carbohydrates.

Photosynthetic Pigments :

- ✓ Photosynthetic pigments are of three types – **chlorophyll, carotenoids, phycobillins.**
- ✓ Chlorophyll and Carotenoids are **insoluble in water** and can be extend only with organic solvent.
- ✓ Phycobillins are **soluble in water.**
- ✓ Carotenoids include **carotene and xanthophyll.**
- ✓ Different pigments absorb **light of different wavelength.**

Photosynthetic Apparatus (Chloroplast) :

- ✓ Chloroplast is occur / found in **green plants** which is constituent of the photosynthetic apparatus.
- ✓ Typically the chloroplast of higher plant are **destroyed in shape.**
- ✓ The chloroplast is **bounded by two membrane** consisting of **lipid bilayer and protein.**
- ✓ Internally, the chloroplast is **filled with hydrophillic matrix called stroma in which are embedded grana.**
- ✓ Each granum consist of **2 to 5 granum (grana lamella)** placed on above the other like a **stack of coils.**
- ✓ In cross section, these lamelli are paired to form **sad like structure** and have been called **thyllakoid.**

- ✓ In higher plants, there are **chlorophyll a, chlorophyll b, carotene and xanthophyll** as main photosynthetic pigments.

Structure of Chloroplast :

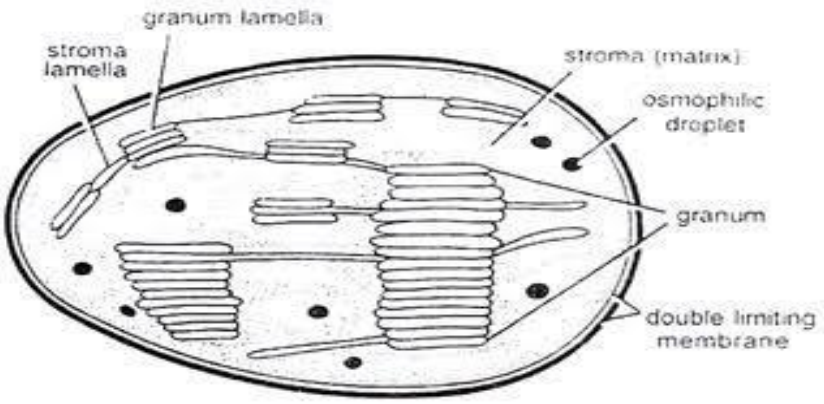

Fig. 295. Structure of chloroplast (redrawn after electron micrograph).

Emersion Effect :

- ✓ The emersion effect is the **increase in the rate of photosynthesis after chloroplast are length of wavelength 680 nm (deep red spectrum) and more than 680 nm (far red spectrum).**
- ✓ When simultaneously exposed to light of both wavelengths, the rate of photosynthesis is **far higher than the sum of the red light and far red light photosynthesis rates.**
- ✓ The effect was early evidence that **two photosystems, processing different wavelengths, cooperate in photosynthesis.**

Difference Between Light and Dark Reaction :

Sr. No.	Light Reaction	Dark Reaction
1.	Light reaction is the **first phase of photosynthesis.**	Dark reaction is the **second phase of photosynthesis.**
2.	Light phase of photosynthesis **occurs in grana.**	Dark phase of photosynthesis **occurs in stroma.**
3.	Light reaction is a p**hotochemical phase of photosynthesis.**	Dark reaction is a **biochemical phase of photosynthesis.**
4.	There is **photolysis of water during light reaction.**	There is **no photolysis of water during dark reaction**.
5.	There is **no fixation of** CO_2 during light reaction.	CO_2 **is fix** during dark reaction.

6.	Light reaction releases **oxygen.**	Dark reaction utilizes CO_2.
7.	Light reaction involves **cyclic and noncyclic photophosphorylation.**	Dark reaction in involves **Calvin cycle, C4 pathway and CAM plants.**
8.	The end products of light are **ATP and NADPH2 .**	The end products of dark reaction are **ADP, NADP and Glucose.**

Difference Between Cyclic and Non-Cyclic Photophosphorylation :

Sr. No.	Cyclic Photophosphorylation	Non-Cyclic Photophosphorylation
1.	In cyclic photophosphorylation, **the electrons expelled from the reaction centre ultimately return to the same reaction centre following a cyclic path.**	In non-cyclic photophosphorylation, **the electrons expelled from the reaction centre do not return to the same reaction centre.**
2.	Cyclic Photophosphorylation is **not accompanied by the evolution of oxygen.**	Non-Cyclic Photophosphorylation is **accompanied by the evolution of oxygen.**
3.	During cyclic photophosphorylation only **ATP is produced**.	During non-cyclic photophosphorylation, **both ATP and NADPH (reduced form of nicotinamide adenine dinucleotide phosphate) are produced.**
4.	Cyclic Photophosphorylation **does not involve the photolysis of water.**	Non-Cyclic Photophosphorylation involves the **photolysis of water.**
5.	**Plastoquinone is does not take part** in cyclic photophosphorylation.	**Plastoquinone play an important role during non-cyclic photophosphorylation.**

Significance of Light Reaction :

- ✓ Light reaction takes place in **chlorophyll in the presence of light.**
- ✓ During light reaction**, the assimilatory powers ATP and NADP2 are synthesized.**
- ✓ The assimilatory powers are used in dark reaction for the **conversion of CO_2 into sugar.**
- ✓ Photolysis of water of occurs light reaction, **the H^+ positive ions release from motor are used for synthesis of NADPH2.**
- ✓ Plant releases **oxygen during light reaction.**

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Lecture 9 :- Dark reaction- C3, C4 and CAM plants factors affecting photosynthesis, Photorespiration.

Dark Reaction :

- ✓ Dark Reaction is the second phase of photosynthesis in which CO_2 **is fix or reduced due to glucose.**
- ✓ It occurs in the **stroma of chloroplast.**
- ✓ **It is independent of light (does not require direct light) hence called Dark Reaction.**
- ✓ The products of light reaction namely as **ATP** and **NADPH2** are used here.
- ✓ This is also called as **Blackman Reaction**.

C_3 Pathway (Calvin Cycle) :

- ✓ In C3 pathway, **CO2 is fixed by RUBP**.
- ✓ Main enzyme involved is **RUBP carboxylase.**
- ✓ The first product of photosynthesis in C3 pathway is a **3-Carbon compound i.e. PGA (phosphogylceric acid).**
- ✓ In C3 pathway, **only one type of chloroplast is involved.**
- ✓ C3 pathway (calvin cycle) is **operative in algae and dicots.**

C4 Pathway (HSK Pathway) :

- ✓ In C4 pathway, **CO2 is fixed by PEPA.**
- ✓ Main enzyme involved is **PEPA carboxylase.**
- ✓ The first product of photosynthesis in C4 pathway is **4-Carbon compound i.e. OAA (Oxaloacetic Acid).**
- ✓ In C4 pathway, two types of chloroplasts **i.e. mesophyll chloroplast and bundle sheath chloroplasts are involved.**
- ✓ C4 pathway is **operative in monocots and in some dicots.**
- ✓ Pyruvic acid is converted into **PEPA (phosphoenol pyruvic acid) to continue C4 pathway.**
- ✓ E.g. **Sugarcane, Sorghum, Maize, etc.**

CAM Plants (Crassulacean Acid Metabolism) :

- ✓ In CAM plants the **C4 pathway and C3 pathway takes place only in mesophyll chloroplast.**
- ✓ In CAM plant, **C4 pathway functions in the night while C3 pathway functions during the daytime.**
- ✓ **Bundle sheath chloroplast are absent** in CAM plants.
- ✓ **Pyruvic acid gets converted into starch by a series of reaction in daytime PEPA is regenerated during night time e.g. Opuntia, Euphorbia, etc.**

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- ✓ In CAM plants, **the stomata are closed during the day time, as it is an adaptation to minimise the loss of water.**
- ✓ In CAM plants, **the stomata remain open during night time.**
- ✓ In CAM plants, therefore**, CO2 enters through the stomata during the night time only.**

Factors Affecting Photosynthesis :

<u>Lecture 9 :- Respiration - Definition, Types of Respiration, Glycolysis TCA cycle and electron transport chain.</u>

Respiration :

- ✓ Respiration is a **oxidation-reduction process in which food materials are broken down into simpler product and energy is released.**
- ✓ **Photosynthesis and Respiration** on both metabolic process.
- ✓ The process of respiration **plays an important role in growth and repair mechanism.**
- ✓ Respiration provides **source of energy for cell division, growth, repairs and replacement of worn out parts, for movement and locomotion.**
- ✓ The General Equation of Respiration –
  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 674$ kcal

Types of Respiration :

There are two types of respiration i.e. **aerobic respiration and anaerobic respiration.**

Sr. No.	Aerobic Respiration	Anaerobic Respiration
1.	Aerobic respiration requires **molecular oxygen**.	Anaerobic respiration does not require molecular oxygen.
2.	Aerobic respiration occurs in **cytoplasm** and **mitochondria.**	Anaerobic respiration occurs in **cytoplasm only**.
3.	The end products are **carbon dioxide** and **water**.	The end products are **carbon dioxide** and **C_2H_5OH**
4.	**Large amount of energy is liberated** during aerobic respiration.	**Small amount of energy is liberated** during anaerobic respiration.
5.	In aerobic respiration, **the respiratory materials are completely oxidised**.	In anaerobic respiration, **the respiratory materials are incompletely oxidised**
6.	During aerobic respiration, **38 ATP molecules are generated.**	During anaerobic respiration, **only 2 ATP molecules are generated.**

7.	Reaction : **$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + 686$ kcal**	Reaction : **$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 50$ kcal**

Anaerobic Respiration :

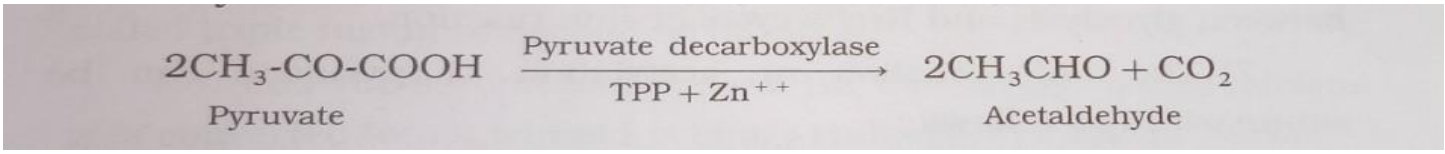
Respiration in the absence of molecular oxygen is called as anaerobic respiration.

Mechanism of Anaerobic Respiration : Anaerobic Respiration occurs in the following three steps :

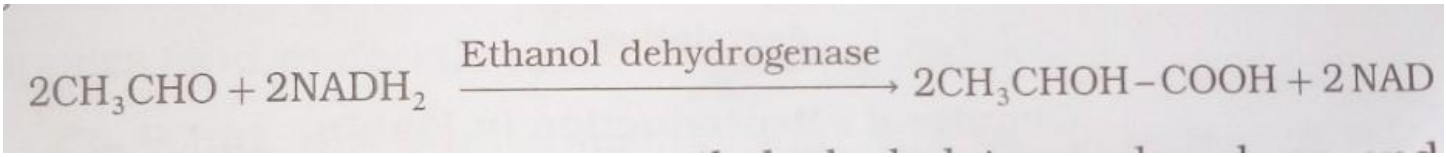
a) **Glycolysis :** During glycolysis glucose is breakdown to 2 molecules of pyruvate to molecules of NADH2 and 2 molecules of ATP along EMP pathway.

$C_6H_{12}O_6 + 2NAD + 2ADP + 2iP \rightarrow 2CH_3CO.COOH + 2NADH_2 + 2ATP$

b) **Decarboxylation :** The pyruvate undergoes decarboxylation to form acetaldehyde. This reaction occurs in the presence of pyruvate decarboxylase enzyme which requires TTP (thymine pyrophosphate) as coenzyme and Zn++ as cofactor.



c) **Reduction :** The acetaldehyde is finally reduced ethyl alcohol biosafety hydrogen atoms from NADH2 produced during glycolysis. This reaction occurs in the presence of enzyme ethanol dehydrogenase.



During this process, since ethyl alcohol is produced, as end product, it is used in fermentation industries for the production of alcohol form molasses. It is also used in bakeries.

The overall equation of anaerobic respiration can be summarized as follows:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + 2ATP$