

NATURE OF LIVING ORGANISM

What are living organisms?

These are organisms characterized by performance of certain life processes. Non living things may be able to perform one or more to these process, for instance, a machine can move, it is only living organism that can perform all of the activities.

Example of living things are: microorganism e.g bacteria, Algae, fungi, lower green plants, non flowering (gymnosperms), flowering plants (Angiosperms) and animals.

Majority of agricultural plants otherwise known as crops are generally found with the non flowering and flowering plants.

Performance of these basic activities by the plant has been of immense benefits to man. For instance, Plants' efforts at feeding through the process of photosynthesis bring about accumulation of starch in maize, cassava, rice, yam, e.t.c. and lipids in groundnut, palm kernel seed e.t.c. As a result of the primary role of plant in food manufacturing, they are referred to as **PRIMARY PRODUCERS**.

We shall restrict our exploit in this class to plant in general and in particular those of agricultural importance. The processes in questions are: Movement, Respiration, Nutrition, Irritability, Growth, Excretion, Reproduction Intractability and Aging.

Movement (locomotion)

Movement in plant involves some parts of its body.

Movement in plant is quite different from that of animals. While animals move the whole body from one place to another (locomotion), plant move some parts of its body. Movement of materials over long and short distances also contribute to movements in plants.

Respiration: This is the process whereby food taken in is oxidised and energy is released for other life processes.

Nutrition: This is intake of simple raw materials by plant and their synthesis into food. Food is used by living things to construct and maintain life.

Irritability: This is also referred to as sensitivity and responsiveness. It is the process of responding to changes in the surrounding or environment.

Growth: The process in which an increase in size of an organism is referred to as growth. This is brought about by the combined efforts of all other processes such as feeding, respiration e.t.c.

Excretion: This is the removal of waste products from chemical reactions which have occurred in organisms.

Reproduction: Every living thing has the capacity to reproduce its type to ensure continuity, avoid extinction.

Intractaction: Every living thing has capacity to interact with its type or other living things. Plants intract with lower as well as higher animals and other plants. They also intract with micro organisms all in effort to sustain the ecosystem. This is a very important concept in ecology.

Aging: All living develops from one stage to the other as time pass on them. This leads to aging from juvenile through maturity and senescence.

The summary is therefore **MR NIGERIA**

Plant nutrition, Elements and their function

Plant nutrition is the study of the chemical elements that are necessary for plant growth. There are several principles that apply to plant nutrition. Some elements are directly involved in plant metabolism (Arnon and Stout, 1939). Metabolism is the life sustaining chemical activity, i.e. The series of processes by which food is converted into the energy and products needed to sustain life. However, this principle

does not account for the so-called beneficial elements, whose presence, while not required, has clear positive effects on plant growth.

Plant nutrition is a difficult subject to understand completely, partially because of the variation between different plants and even between different species or individuals of a given clone. Elements present at low levels may cause deficiency symptoms, and toxicity is possible at levels that are too high. Further, deficiency of one element may present as symptoms of toxicity from another element, and vice-versa. Carbon and oxygen are absorbed from the air, while other nutrients are absorbed from the soil. Green plants obtain their carbohydrate supply from the carbon dioxide in the air by the process of photosynthesis

A nutrient that is able to limit plant growth according to Liebig's law of the minimum, is considered an essential plant nutrient if the plant can not complete its full life cycle without it.

There are 16 essential plant nutrients.

Macronutrients:

- N = Nitrogen
- P = Phosphorus
- K = Potassium
- Ca = Calcium
- Mg = Magnesium
- S = Sulfur
- Si = Silicon

Micronutrients (trace levels) These are elements that are vital to plant growth but are only required in minute amounts, very much like vitamins in human diets. They are known as micronutrients because of the tiny amounts found in normal soils. For the average home vegetable

growing micro nutrients are an academic rather than a practical subject. Identifying micro nutrient deficiencies is difficult even for experts and usually requires laboratory analysis. With iron deficiency, even laboratory analysis is difficult. Luckily for us, most of these deficiencies are very rare and rotation, use of compost and manures will cure them. These elements include:

- Cl = Chlorine
- Fe = Iron
- B = Boron
- Mn = Manganese
- Na = Sodium
- Zn = Zinc
- Cu = Copper
- Ni = Nickel
- Mo = Molybdenum

These nutrients are further divided into the mobile and immobile nutrients. A plant will always supply more nutrients to its younger leaves than its older ones, so when nutrients are mobile, the lack of nutrients is first visible on older leaves. When a nutrient is less mobile, the younger leaves suffer because the nutrient does not move up to them but stays lower in the older leaves. Nitrogen, phosphorus, and potassium are mobile nutrients, while the others have varying degrees of mobility.

Plants uptake essential elements from the soil through their roots and from the air (mainly consisting of nitrogen and oxygen) through their leaves. Nutrient uptake in the soil is achieved by cation exchange, wherein root hairs pump hydrogen ions (H^+) into the soil through proton

pumps. These hydrogen ions displace cations attached to negatively charged soil particles so that the cations are available for uptake by the root. In the leaves, stomata open to take in carbon dioxide and expel oxygen. The carbon dioxide molecules are used as the carbon source in photosynthesis.

Though nitrogen is plentiful in the Earth's atmosphere, relatively few plants engage in nitrogen fixation (conversion of atmospheric nitrogen to a biologically useful form). Most plants therefore require nitrogen compounds to be present in the soil in which they grow.

Functions of nutrients

Each of these nutrients is used in a different place for a different essential function.

Carbon

Carbon forms the backbone of many plants biomolecules, including starches and cellulose. Carbon is fixed through photosynthesis from the carbon dioxide in the air and is a part of the carbohydrates that store energy in the plant.

Hydrogen

Hydrogen also is necessary for building sugars and building the plant. It is obtained almost entirely from water.

Oxygen

Oxygen is necessary for cellular respiration. Cellular respiration is the process of generating energy-rich adenosine triphosphate (ATP) via the consumption of sugars made in photosynthesis. Oxygen gas is produced as a by-product from this reaction.

Phosphorus

Phosphorus is important in plant bioenergetics. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus can also be used to modify the activity of various enzymes by phosphorylation, and can be used for cell signalling. Since ATP can be used for the biosynthesis of many plant biomolecules, phosphorus is important for plant growth and flower/seed formation.

Potassium

Potassium regulates the opening and closing of the stoma by a potassium ion pump. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases drought tolerance. Potassium deficiency may cause necrosis or interveinal chlorosis.

Nitrogen

Nitrogen is an essential component of all proteins. Nitrogen deficiency most often results in stunted growth.

Sulphur

Sulphur is a structural component of some amino acids and vitamins, and is essential in the manufacturing of chloroplasts.

Silicon

Silicon is deposited in cell walls and contributes to its mechanical properties including rigidity and elasticity

Calcium

Calcium regulates transport of other nutrients into the plant and is also involved in the activation of certain plant enzymes. Calcium deficiency results in stunting.

Magnesium

Magnesium is an important part of chlorophyll, a critical plant pigment important in photosynthesis. It is important in the production of ATP through its role as an enzyme cofactor. Magnesium deficiency can result in interveinal chlorosis.

Iron

Iron is necessary for photosynthesis and is present as an enzyme cofactor in plants. Iron deficiency can result in interveinal chlorosis and necrosis.

Boron (B)

Boron is necessary for calcium to perform its functions in the plant but too much boron is also harmful to the plant. Excess use of magnesium sulphate will also cause a boron imbalance. The symptoms of boron deficiency are poor development of the growing tip of the plant. It is more likely in soils with pH above 6.5.

Confirming boron deficiency is a job for laboratory analysis. Adding borax to the soil will correct the deficiency but borax is also a herbicide. For garden growers who are unlikely to want to pay for professional testing and recommendations the best advice is to avoid over use of magnesium sulphate, rotate and use plenty of home made compost.

Copper (Cu)

Copper deficiency is rare but can occur on sandy, peaty and chalky soils with their high pH levels. It is required for root formation. Once again it requires professional analysis to confirm and to determine a proper course of action to rectify. Usually the single use of a copper sulphate based fungicide (Bordeaux mixture) will re-stock the soil for as long as you

are likely to grow on it. Excess copper is very toxic to plants and to people. In plants it causes reduced growth, yellowing of the foliage, and stunted root development

Iron (Fe)

Iron deficiency causes yellowing of the leaves and a general lack of vigour. It is fortunately rare but unfortunately hard to both diagnose or determine by laboratory analysis. Generally not something the home grower needs to concern himself with but should you suspect you have it then use sulphate of iron fertilizer

Manganese (Mn)

Manganese deficiency is often caused by over liming and is most often found on peaty and sandy soils with a high pH. Symptoms are similar to iron deficiency and can be confirmed by laboratory analysis of the leaf. Susceptible crops include peas and beets.

Adding sulphur to the soil, which will increase the acidity (decreasing pH) will solve the problem.

The following micro-nutrients are rarely lacking and analysis and remedy are professional jobs. Normal additions of composts and manures will resolve deficiency problems. Excess in the soil will probably be due to industrial contamination.

Molybdenum (Mo)

Molybdenum is only required in minute amounts. Molybdenum is a cofactor to enzymes important in building amino acids. Excess of it is as harmful as molybdenum deficiency.

Zinc (Zn)

Zinc deficiency is more likely in soils with high pH than low. Crops most sensitive are tomatoes, onions and beans.

Boron

Boron is important in sugar transport, cell division, and synthesizing certain enzymes. Boron deficiency causes necrosis in young leaves and stunting of plants.

Copper

Copper is important for photosynthesis. Symptoms for copper deficiency include chlorosis. Involved in many enzyme processes. Necessary for proper photosynthesis. Involved in the manufacture of lignin (cell walls). Involved in grain production.

Manganese

Manganese is necessary for building the chloroplasts. Manganese deficiency may result in coloration abnormalities, such as discolored spots on the foliage.

Sodium

Sodium is involved in the regeneration of phosphoenolpyruvate in CAM and C4 plants. It can also substitute for potassium in some circumstances.

Zinc

Zinc is required in a large number of enzymes and plays an essential role in DNA transcription. A typical symptom of zinc deficiency is the stunted growth of leaves, commonly known as "little leaf" and is caused by the oxidative degradation of the growth hormone auxin.

Nickel

In higher plants, Nickel is essential for activation of urease, an enzyme involved with nitrogen metabolism that is required to process urea. Without Nickel, toxic levels of urea accumulate, leading to the formation of necrotic lesions. In lower plants, Nickel activates several enzymes involved in a variety of processes, and can substitute for Zinc and Iron as a cofactor in some enzymes. ^[citation needed]

Chlorine

Chlorine is necessary for osmosis and ionic balance; it also plays a role in photosynthesis.

Cobalt has proven to be beneficial to at least some plants, but is essential in others, such as legumes where it is required for nitrogen fixation. Vanadium may be required by some plants, but at very low concentrations. It may also be substituting for molybdenum. Selenium and sodium may also be beneficial. Sodium can replace potassium's regulation of stomatal opening and closing.

Uptake of nutrients (Absorption and conduction)

Green plants absorb H₂O and inorganic salts from the soil through the unicellular hairs and the main roots. Absorption of H₂O by the root and root hair is a passive absorption i.e. energy is required and the normal process of diffusion of osmosis is implicated here. However, absorption of dissolved ions can either be passive or active.

II. Nutrient uptake

A. *Root hairs* of epidermal cells

1. Increase surface area for absorption.
2. Contain membrane proteins, which selectively facilitate ion passage

B. Mechanisms of nutrient uptake

1. *Passive uptake* occurs when an electrochemical gradient favours ion movement, and diffusion occurs through nutrient specific channels in the cell membrane.

2. Active transport of ions can occur against an electrochemical gradient if proton pumps and specific co-transporters are present within the root-hair cell membrane.

C. Nutrient transfer via mycorrhizal fungi

1. *Mycorrhizae*: *Mutualistic* associations with plant roots.

2. Fungus absorbs nitrogen and phosphorus from soil and provides them to plant.

3. Plant provides sugar to the fungus.

IV. Nitrogen Fixation

Bacteria and pea-family plants form species-specific mutualistic associations.

II. Soil

A. Texture and composition of soil depend on parent rock.

1. Texture affects oxygen availability and root penetration.

2. Composition affects nutrient availability.

B. Nutrient availability

1. Nutrients are in the form of positively or negatively charged ions

2. Positively charged ions tend to bind to organic matter as well as clay.

3. Negatively charged phosphates also bind to organic matter.

4. Soils without organic matter and clay lose nutrients fast.

Sources of metabolites

Metabolites are the intermediates and products of metabolism. The term *metabolite* is usually restricted to small molecules. A **primary metabolite** is directly involved in normal growth, development, and reproduction. A secondary metabolite is not directly involved in those

processes, but usually has an important ecological function. Examples include antibiotics and pigments.

The metabolome forms a large network of metabolic reactions, where outputs from one enzymatic chemical reaction are inputs to other chemical reactions.

Metabolites from chemical compounds, whether inherent or pharmaceutical, are formed as part of the natural biochemical process of degrading and eliminating the compounds. The rate of degradation of a compound is an important determinant of the duration and intensity of its action. Profiling metabolites of pharmaceutical compounds, drug metabolism, is an important part of drug discovery, leading to an understanding of any undesirable side effects.

Secondary metabolite

This is natural chemical product of plants not normally involved in primary metabolic processes such as photosynthesis and cell respiration. Also known as secondary plant product.

Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of organisms. Unlike primary metabolites, absence of secondary metabolites does not result in immediate death, but rather in long-term impairment of the organism's survivability, fecundity, or aesthetics, or perhaps in no significant change at all. Secondary metabolites are often restricted to a narrow set of species within a phylogenetic group.

CHEMOSYNTHESIS

This is the transformation of one form of chemical energy into another. Colourless autotrophic bacterial are able to synthesize carbohydrate without light as the source of energy. These bacteria are aerobic and the energy required in the metabolic process is derived from oxidation of certain inorganic compounds present in their environment.

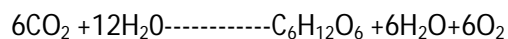
The energy released in the oxidation process is used to convert CO₂ to carbohydrates and other organic compounds such as protein, fats, etc.

Bacteria do not use water as in the normal photosynthesis hence, there is no release of oxygen. Examples of these bacteria are sulphur bacteria, iron bacteria and nitrifying bacteria. Sulphur bacteria synthesize organic compounds from CO₂ using energy derived from oxidation of hydrogen sulphide (H₂S), sulphur is deposited on the bacteria cell.

Iron bacteria obtain energy from the oxidation of ferrous hydroxide to ferric dioxide.

PHOTOSYNTHESIS

This is the manufacturing of simple carbohydrates such as sugar in the green leaves by the chlorophyll in the presence of sunlight (as a source of energy) from CO₂ and water absorbed from the soil and oxygen is liberated. By this process, a large amount of energy is formed by the green cell into chemical energy and stored in the organic substances formed. Glucose or fructose appears to be the first carbohydrate formed in photosynthesis.



There are two phases in photosynthesis. The **LIGHT** phase and the **DARK** phase.

The light phase involves a series of chemical reactions of which light is indispensable and therefore called light reaction.

This involves adsorption of light by chlorophyll, splitting of water molecules with the production of reducing agent (NADP).

The dark phase which does not require light is a series of chemical reactions of CO₂ (fixation of carbon dioxide) by reducing agent produced during the light phase to organic compounds.

Important steps in light phase

Chlorophyll pigments absorb light energy from sunlight and become activated.

The energy stored in the chlorophyll goes to break up water molecule (Photolysis/photolysis of water) to give energized electron and oxygen. The energy of the electron is used to synthesis ATP.

The energized electrons are accepted by electron acceptor and are eventually used to reduce NADP to NADPH, a reducing agent needed in the dark phase

One or more ATP molecules may be formed. The products of the light phase are therefore **ATP** and **NADPH** which are needed in the dark phase.

Important steps in dark phase

All reduction steps from CO₂ to sugar are dark reactions.

A 5-carbon compound, ribulose-phosphate is activated by ATP to form Ribulose di-phosphate (RuDP) also a 5 carbon compound.

The RuDP combines with CO₂ to form an unstable 6 carbon complex.

The complex split into two parts, one of which is a stable 3 carbon compound called phosphoglyceric acid.

Many of the remaining portions of the splitting complex is used to re-form ribulose phosphate which fed into the chain of reaction to continue the process.

There is further activation of phosphoglyceric acid to di-phosphoglyceric acid using ATP.

Diphosphoglyceric acid is reduced to diphosphoglyceraldehyde by the reducing agent NADPH

6-carbon hexose sugars e.g. glucose or fructose are formed from many molecules of 3-carbon phosphoglyceraldehyde.

All the steps are catalyzed by many enzymes.

Sugar or starch is not the only end products of photosynthesis. Phosphoglyceraldehyde, lipids, protein could also be formed depending on the requirements of the plant at the time.

All these reactions take place in the chlorophyll located in the chloroplast in the leaf of plant.

C₃ Plants

These are plants in which CO₂ fixation is dependent on the enzyme Ribulose 1, 5- diphosphate carboxylase (RUDP). Majority of plant sp. fall into this category e.g slow-growing perennials, desert sp, trees and shrubs in the tropics and the sub tropics, deciduous wooden plants, horticultural plants, agronomic plants like soybeans and cotton e.t.c.

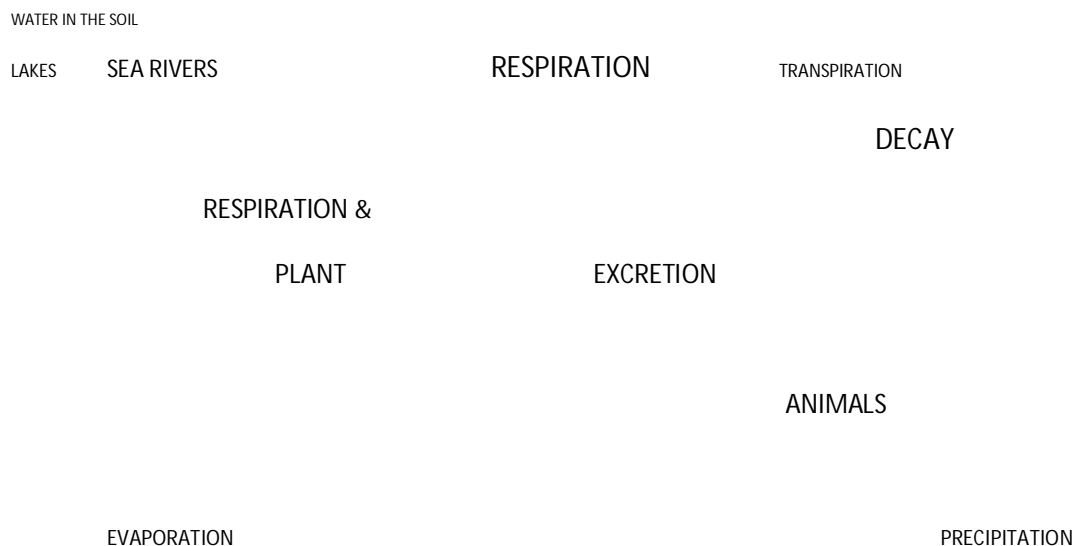
C₄ Plants

These are plants which possesses an additional photosynthetic system. They have high rate of photosynthesis and in turn rapid growth. They ensure high turnover of assimilate, no resistance to the inward diffusion of CO₂. Their CO₂ fixation system is principally due to enzyme phosphophenol pyruvate (PEP) carboxylatase. Examples are tropical grasses, sugarcane, corn, e.t.c.

CYCLES OF RAW MATERIALS IN NATURE

Substances are utilized by plants; animals utilize plants and some of the raw chemical; When they die, their remains are subjected to the decaying action of micro-organisms. The raw materials are put back into circulation. There is thus, for all these raw materials a broad cycle of absorption utilization and ultimate return to the raw material status e.g

DIAGRAM OF WATER CYCLE AND CARBON



OSMOSIS.

Usually, there is a movement of water from the dilute solution outside the cell to the strong solution inside. This movement between solutions separated by membrane is termed osmosis. Plasmolysis is a special type of osmosis that occurs when a stronger solution is outside the membrane than the solution which is contained within the cell. Normal plant cells consist of relatively stronger solution of sugars, salts, pigments, etc and a dilute solution outside the cell.

Transport system in plants

The large number of cells present within a leaf provides a very large surface of contact to the internal atmosphere of the leaf. However, the cells are still perfused with liquid, which is contained in the cell walls since these must be kept moist. If the cell walls are not moistened by liquid derived from the vacuole tissue, the gases of the atmosphere would not be able dissolve and so come into contact with the surface of the protoplasm. Under the conditions of photosynthesis in plant, evaporation of water from the leaf surface is inevitable and this is called transpiration. Water loss through this evaporation or transpiration needs to be replaced by absorption from the soil and movement in the conducting vessels of the xylem. This accounts for how water or sap gets to the top of a tall tree. Because the surface of the root lacks cuticles, it is in direct contact with the moisture in the soil which when free to move, can penetrate through the cortex of the root.

Water and salts enter the root hairs simultaneously and are released to the xylem vessel for uptake via the transpiration stream. The diffusive movement of salt is in the opposite direction from the region of higher to those of lower concentrations. The cells expend energy in causing salts to move against the diffusion gradient. The necessary energy is gotten from the active metabolism of the tissues and the term active absorbs ion and **active transport** are used to describe such movement of salt that is dependent on metabolic activity. The movement of water to the xylem and the subsequent upward movement through the transpiration stream are referred to as **passive uptake**. Hence uptake of nutrient

from the soil requires expenditure of energy by the root otherwise, there will be the tendency for the nutrient to leach out of the tissue when the concentration is high and this does not occur. The roots are therefore capable of accumulating ions in their cells and also selectively take up ions from the soil. For this capability, the root requires energy for respiration, hence the importance of soil aeration to plant roots.

Mechanisms affecting the movement of water in the plant

If a plant is cut a few cm above the soil level, an exudation of water (containing small amount of salts) is often found to occur from the stump. With this, a small amount of hydrostatic pressure is often set up. This pressure is deemed to be from the root. Closely related to this is the exudation (or guttation) of drops of water from the leaves of intact plants. Guttation appears to be due to the root pressure mechanism which continues to force water up during the night when transpiration is very slow, owing to the closure of the stomata. The plant becomes gorged with water, and the latter is forced out in liquid form from hydathodes. It is thought, however, that root pressure alone is inadequate to account for the upward flow of the transpiration stream especially in shrubs and trees.

Cohesion force

Water molecules have strong attractions towards each other; hence they pull each along a gradient upward the stem.

Adhesion

Water molecules have tendency toward attaching to their containers (the cell wall in this case) hence they move up along the side of the xylem vessels. This explains the shape the meniscus of water in a cylinder.

Respiration

Basic concepts: Respiration, Redox reaction, glycolysis, glycogenesis, biological polymer, electron transport system, phosphorylation types (photophosphorylation, oxidative phosphorylation, transphosphorylation)

Learning Objectives:

1. Understanding of the basic principle of respiration
2. Understanding of the mechanism of respiration
3. Comparative analysis of aerobic and anaerobic (Fermentation) respiration
4. Factors affecting respiration
5. Importance of respiration in agricultural process

Theoretical background:

Plants are living system, thermodynamically opened to the exchange of energy and matter with the environment. Among the basic characteristics of any living system is the process of transformation of energy or metabolic process. Conceptually, this process could be classified into two catabolic and anabolic processes. Anabolic process is the transformation of energy and matter towards the building of complex biological polymer. An example of such a process is photosynthesis. Catabolic process on the other hand involves breakdown of such biological polymer and the consequent release of energy and other products of metabolism. Respiration is an example of a catabolic process.

Respiration is a bio-oxidative process; involving loss of electron, proton and the addition of oxygen. Oxidative process is coupled with reduction, hence the process is better characterised as a redox reaction with the formation of energy in the form of ATP, the energy currency of living system. Table 4 provides a conceptual framework of respiration. Respiration in plant is mediated via passive diffusion of gases, with no specialised organ and carrier as obtainable in animals.

Table 1 Dimensions of respiration

Questions dimensions	Responses
What	Biooxidative-reductive process
Why	<ol style="list-style-type: none"> 1. Energy is released which is consumed in various metabolic processes essential for plant and activates cell division 2. It brings about the formation of other necessary compounds participating as important cell constituents 3. It converts insoluble food into soluble form 4. It liberates carbon dioxide and plays a part actively in maintaining the balance of carbon cycle in nature 5. It converts stored energy (potential energy) into usable form (Kinetic energy)
How	<p>Initial degradation (hydrolysis)-Partial degradation (glycolysis/EMP/oxidative pentose phosphate pathway/Enter-Doudoroff pathway)-Total degradation (Krebs cycle and electronic transport system)</p> $ \begin{array}{ccccccc} \text{C}_6\text{H}_{12}\text{O}_6 & + & 6\text{O}_2 & \longrightarrow & 6\text{CO}_2 & + & 6\text{H}_2\text{O} & + & \text{energy} \\ \text{glucose} & & \text{oxygen} & & \text{carbon} & & \text{water} & & \\ & & & & \text{dioxide} & & & & \end{array} $
Where	<ul style="list-style-type: none"> • Cytosol • Mitochondria

When	Throughout the life of the plant
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Find below a flow chart depicting the mechanism of respiration in plants (Figure 1)

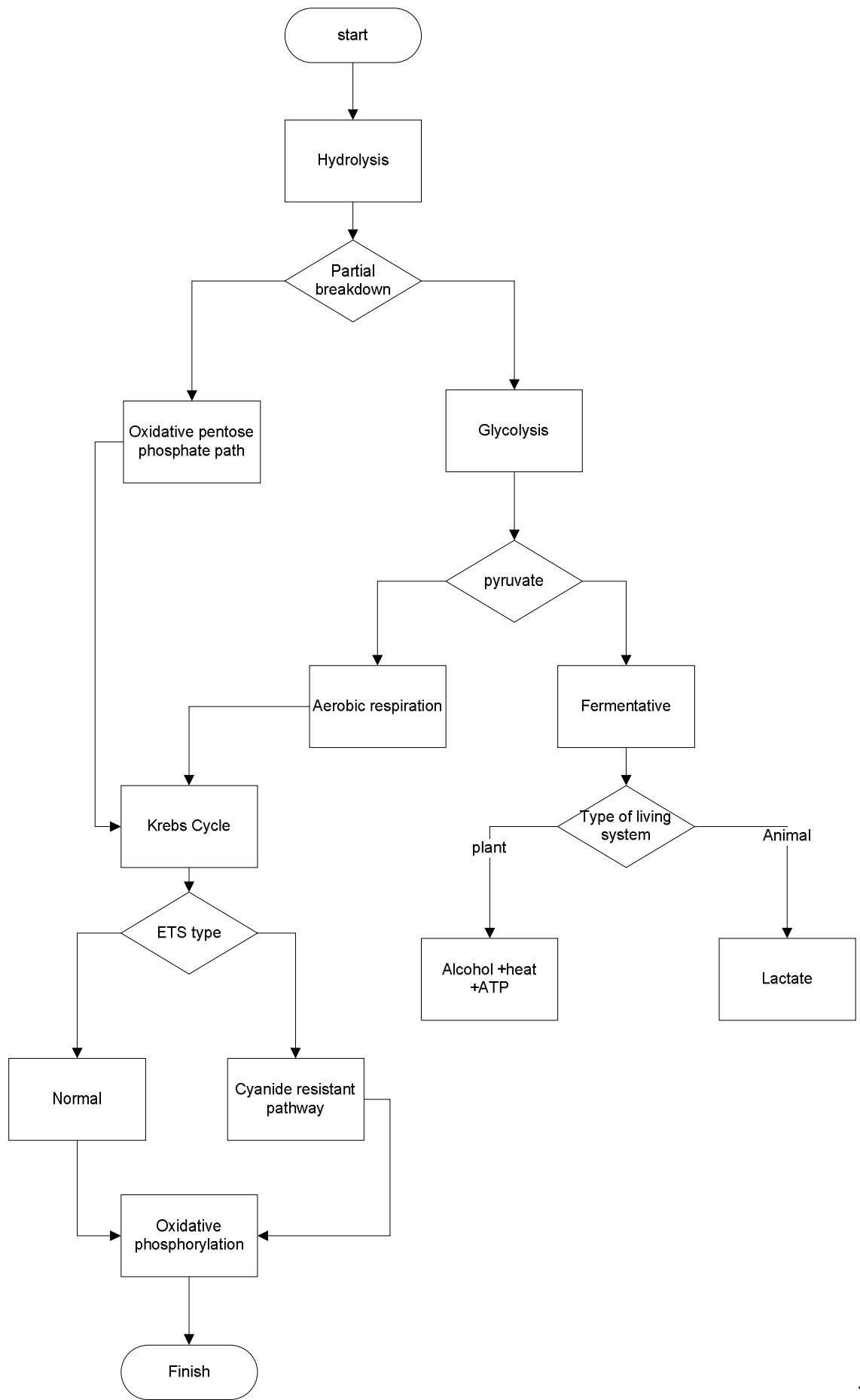


Table 2

Distinction between aerobic and anaerobic respiration

S/N	Aerobic respiration	Anaerobic respiration
1	It is common to all plants	It is a rare occurrence
2	It goes on throughout the life	It occurs for a temporary phase of life
3	Energy is liberated in larger quantity. In total, 38 ATP molecules are formed	Energy is liberated in lesser quantity. Only 2 ATP molecules are formed
4	The process is not toxic to plants	It is toxic to plants
5	Oxygen is utilised during the process	It occurs in the absence of oxygen
6	The carbohydrates are oxidised completely and are broken down into CO ₂ and H ₂ O	The carbohydrates are oxidised incompletely and ethyl alcohol and carbon dioxide are formed
7	The end-products are CO ₂ and H ₂ O	The end-products are ethyl alcohol and carbon dioxide
8	The process takes place partly in cytosol (glycolysis) and partly inside mitochondria (Krebs cycle)	The process occurs only in the cytosol

OSMOREGULATION AND METHODS OF ELIMINATION OF WASTE MATERIALS IN PLANT

Basic concepts: Osmoregulation, transport, transporters, active and passive transport, primary and secondary transport, symport, antiport

Learning objectives:

1. Water balance in plants and strategies for acclimation and adaptation
2. Osmoregulation as a mechanism for maintaining water balance in plant
3. Methods of eliminating waste product in plants
4. Transport mechanism in plant

Theoretical background

Water is very vital towards increased agricultural productivity. Agricultural practise in the topics is greatly hampered by **Abiotic stressors**, namely; drought and heat shock. The presence of these stressors elicit water deficit leading to reduced growth and development in cultivated crop, eventually reducing agricultural productivity. **Salinity** due to inappropriate use of irrigation water or cultivation of crops in soils of high concentration of salt could lead to accumulation of toxic substances in plants. Water balance in plants has to be maintained. Different strategies were devised by plants in combating the adverse effects of osmotic stress towards the maintenance of water.

At the molecular level were observed the following osmoregulatory strategies:

- Synthesis and accumulation of **osmolytes** and **osmoprotectants**
 - Organic nitrogen-containing
 - Organic non-nitrogen containing
- Uptake of compatible ions
- Extrusion, sequestration and compartmentalisation of incompatible ions

The advent of osmotic stress in most crop leads to synthesis and accumulation of osmolytes and osmoprotecting substances.

Among the compatible organic solutes are nitrogen containing:

- Amino acids e.g. proline, glycine betaine
- Amino acids derivatives
- Quaternary amino acids

Non-nitrogen containing:

- Sugars
- Cyclic and acyclic polyols; mannitol, sorbitol
- Fructans
- Sulfonium compounds

Accumulation of these substances in the cell *will not lead* to the disruption of normal metabolic activities, hence the name compatible solute. The mechanism of their action is in the reduction of cellular water potential, thus facilitating movement of water into the cell. Apart from that they have been reported to play a vital role in **osmoprotective** functions such as the protection of the protein stability, scavenging **reactive oxygen radical**, adjustment of cellular **redox state** and **membrane stabilisation**.

In other to lower the water potential of plants with the commencement of osmotic stress, inorganic ions like K^+ are passively absorbed by plant down concentration gradient.

Extrusion, sequestration and compartmentalisation facilitate the removal of toxic ions from the cell or compartmentalisation in another organ where like the vacuole, Golgi bodies or endoplasmic reticulum, where their toxic effect could be greatly ameliorated. The process is mediated actively via the actions of certain transporters like;

1. Channels
 - a. Selective (Potassium Inward Regulated Channel, KIRC; Potassium Outward Regulated Channel, KORC, Aquaporin)
 - b. Non-Selective
2. Carriers; High and low affinity carriers
3. Pumps
 - a. Electrogenic (H^+ /ATP-ase, H^+ /PP)
 - b. Electroneutral

Primary active transport process coupled with the hydrolysis of ATP will lead to the generation of **proton motive force** that will facilitate secondary influx of proton into the cytoplasm or vacuole with other ions transported symportally or antiportally. Apart from regulation of the osmotic status of the cell and water balance, this chemiosmotic regulation could lead to the regulation of nutrient uptake, water balance pH level in the plant and the excretion of toxic waste product of metabolism.

Excretion in plant is the removal from the body toxic waste product of metabolism. Compared to animals, plants do not have as such a specialised organ of excretion. Leaf in most cases act as organ of excretion. Toxic waste product of metabolism like water vapour, carbon dioxide and certain salt are removed from the leaf of the plant.