BIO 103

INTRODUCTORY PHYSIOLOGY

Nature of Living Organisms

Living organisms are characterized by the performance of certain life processes or functions, which distinguish them from non-living things. Non living things may perform one or more of these processes, for example, a crystal can grow and a machine can move. It is only a living organism that can perform all of the following processes at some time in its life.

(1) Movement is one of the whole body in locomotion or part of the body internally or externally in plants and animals. Transport is a process of moving materials over short or long distances within the organism.

(2) Irritability, also called sensitivity and responsiveness is the process of responding to changes in the surroundings or environment.

(3) Feeding or nutrition, is the intake of energy and simple raw materials by plants and their synthesis into food. Food is used by plants and animals to construct and maintain life.

(4) Respiration is the process of releasing energy from food, for the performance of life processes, oxidation of food.

(5) Excretion is the removal of waste products from chemical reactions which have occurred in the organism.

(6) Growth is generally an increase in size of an organism arising from the synthesis of new structural material using the energy provided by respiration and raw materials from outside the organism.

(7) Reproduction occurs at some time in an organism's life and is a process of continuing life of the species by offspring.

Homeostasis

All the life processes occurring in the living organism must be performed in spite of changes in he surrounding environment and of different demands on the organism.

Homeostasis is a self regulating control which keeps the living organism functioning correctly.

Homeostasis can be defined as the maintenance of the steady state in the animal body. Plants may also be considered to show homeostatic adjustment to such stimuli as light, but owing to their sessile nature their systems of physiological co-ordination are mainly much less elaborate than those of animals. Homeostasis can also be defined as a means whereby physiological systems operate both separately and together to buffer against fluctuations from the optimum conditions.

Examples of homeostatic control in animals

System	Cause of fluctuation	Homeostatic control
Circulation	Muscular activity	Increase of heartbeat, blood pressure and supply of blood to the muscles concerned
	Temperature change	Adjustment of blood supply to or from the skin. Sweating or shivering
	pH changes due to metabolic activities	Buffering by haemoglobin phosphates etc. in blood. Release of H^+ or OH^- by kidneys
	Sugar taken up from gut or by activity	Adrenalin, insulin balance
Kidney	Intake of variable quantity of water or ions	Composition and strength of urine controlled by mineral corticoids and antidiuretic hormone
Long muscles	Muscular activity, balance, posture and locomotion	Increased ventilation changes monitored by main sense organs or proprioceptors lead to feedback and appropriate adjustments in antagonistic systems. Control centre is cerebellum
Digestion	Presence of food	Secretion of enzymes peristaltic activity and increased blood supply

The stated adjustments are all co-ordinated by endocrine or the autonomic nervous system from control centres in the brain. In a broader sense, homeostasis may also be said to apply to situations involving the whole organism such as the response of the body to pain, danger and stress.

Mammals are highly evolved animals and their bodies function within very narrow physiological limits. If homoestatic control breaks down death rapidly follows. Thus raising the temperature of the human body by only 3^oC causes widespread functional disorganization. The ability of mammals to maintain their bodies at a steady state despite widespread fluctuations in the environment is one of the major factors determining their success.

PLANT NUTRITION

MATERIAL REQUIREMENTS SOURCES

The raw materials required by green plants are H_2O, CO_2 and is a variety of inorganic ions. The so-called essential elements or macro nutrients are ten: Nitrogen, Phosphorus, sulphur, potassium, calcium and iron (N, P, S, K, Mg, Ca, Fe). Many plants require certain other elements in such small quantities that theyare not known as trace elements or micro nutrients. They include boron, manganese, zinc, copper, molybdenum (B, Mn, Zn, Cu, Mo). The sources of these substances vary with the environment of the plant concerned. Terrestrial plants must be supplied from either the soil or atmosphere.

Carbon enters the plant in combination with oxygen as CO_2 molecules. Hydrogen enters the plant in combination with oxygen as water rmolecule. Oxygen enters the plant in combination with carbon and hydrogen as CO_2 and H_2O. Nitrogen may be obtained by higher green plants from the soil solution and Nitrate ions (NO), though Nitrates and Ammonium ions may also be used. Plants may absorb from the soil soluble nitrogenous material such as Urea amino acid. Phosphorus is absorbed from the soil solution as phosphate ions (PO_4), sulphur is taken as sulphate (SO_{4-4}). Potassium is absorbed as potassium ion (K^+) likewise Magnesium as (Mg^{++}), calcium as

(Ca^{++}), iron as (Fe^{++}), Boron as Bo^{-}), Manganese as Mn^{++}, Zinc is absorbed as Zn^{++}, copper as Cu^{++}.

FUNCTIONS OF ELEMENTS

Carbon: Is used either as structural material as carbohydrate, protein and fat and complexes of these or as respiratory substrates for the supply of energy 45% of dry wt. of plant is carbon constituents.

Hydrogen: Forms part of the structural materials and respiratory substrates. It is associated with biological oxidation reduction process and as Hydrogen ion they influence the reaction of all cell fluids.

Oxygen: Plays a large part in the structure of organic materials and in gaseous form, it is necessary for aerobic respiration.

Nitrogen: Is primarily necessary for formation of amino acid and hence proteins, for the synthesis of purine and pyrimidines and the nitrogenous bases. Lack of Nitrogen leads to yellowness of green plants, stunted growth, retarded flowering and fruiting and general weakness.

Phosphorus: This is always present in nucleotides, nucleoprotein as constituent of nucleus and in celitithin, a constituent of protoplasm. It promotes nuclear and cells division, and is concerned in carbohydrate breakdown in respiration. Phosphorus aids nutrition and hastens maturity and ripening of fruits especially grain. It promotes development of root system. Deficiency becomes apparent as poor root development.

Sulphur: Is contained in some amino acid such as crystine, cystiene and methionine and hence it enters into the composition of some proteins. Some enzymes such as urease and Hexokinase require cystine group for activation. It is important constituent of mustard oil. It may be connected with chlorophyll formation as deficiency makes plant chlorotic with also slender stem.

Potassium: Is connected in meristematics areas. It is essentially a constituent of the protoplasm and is closely connected with its vital activity. It is absent

from the nucleus and plastids. Potassium may be concerned with the electro-osmotic transport mechanism in the synthesis of Carbohydrates and proteins. Deficiency result in weak plants (i.e. growth is checked) under-sized seeds and typical red or purple leaf colouration.

Magnesium: Is constituent of the chlorophyll molecule and this is indispensable. Deficiency leads to chlorosis. It is a part of the structures some of the enzymes of glycolytic reactions and an activatpr in phosphatase and carboxylase system.

Calcium: It enters into the constructions of the plant as a calcium pectate in the middle lamella of cell walls. Cells cannot enlarge in the total absence of calcium. It effects permeability of cell membranes and influences the transport of carbohydrate and proteins. It affects the ability of colloids to absorb water. It is also anti-toxic to various poisonous substances to the plants. It promotes root growth. Deficiency leads to stunting and poor root growth. Crystals of calcium oxalate are of common occurrence in the tissues of many plants.

Iron: Is essential for the pophyrin enzymes of respiration, where it acts as an oxidizing reducing agent, alternately appearing as ferrous and ferric forms. It is essential in chlorophyll formation. Lack of it causes chlorosis.

SOURCES OF METABOLITES

The organic substances used by plants and animals in their metabolic activities were fundamentally the same. They both require carbohydrate, protein, fats and many other organic compounds. Most of these compounds are manufactured by the plants while majority of them have to be presented to the animals in many forms. The metabolites are manufactured by the plants from inorganic materials.

METABOLITES: Are therefore materials involved in metabolic activities for the living cell and these include:

1. Various carbohydrates

2. Nitrogen containing compounds
3. Fats and oils, waxes, etc. (Lipids). These are stored in plant in the endosperm, cotyledons, roots, leaves, stem etc.

VARIOUS CARBOHYDRATES: These are products of C, H, O built from various units called the monosaccharides and named either according to their functional groups or numbers of carbon they have in their structure

(1) NAMING ON BASIS OF FUNCTIONAL GROUPS

Those with:

(___CHO) Aldehyde group are the Aldose forms

(__C = O) Ketone group are the Ketose forms

(2) NAMING ON THE BASIS OF NUMBER OF CARBON ATOMS

Triose,	tetrose,	pentoses	hexoses	heptoses	octoses
(3C)	(4C)	(5C)	(6C)	(7C)	(8C)

Aldose forms will include

CHO	CHO	CHO	CHO
HCOH	HCOH	HCOH	HCOH
CH_2OH	CHOH	HCOH	HCOH
Glycereldehyde	$CH_2OHHCOH$		HCOH
	Erythrose	CH_2OH	HCOH
		Ribose	CH_2OH
			Glucose etc.

The Ketose forms will include:

CH_2OH	CH_2OH	CH_2OH	C
C = O	C = O	C = O	C = O

CH_2OH	HCOH	HCOH	HOCH
Dihydroxy	CH_2OH	HOCH	HCOH
Acetone	Erythrulose	CH_2OH	HCOH
		Ribulose	CH_2OH
			Fructose etc.

Diagram

Some of the monosaccharides e.g. 5c and 6c types can be written in the Pyran or Furan ring above. Dissacharides e.g.

Maltose = (Glucose + Glucose)

Lactose = (Glucose + Galactose)

Polysaccharides e.g.

(a) Storage type – starch

Glucose

(b) Structural type – Cellulose

Agar of (sea weed) etc.

Nitrogen containing compounds

(a) Proteins (b) Purine & Pyrimidines (c) Nucleic acids

Amino acids

Amino acids are compounds with the general formular:

	H				CH		
R	C	COOH		R =	CH	CH_2 =	leucines
	NH_2				CH_3		

R = CH_3 CH_2 CH = Isoleucine

CH_3

R = CH_{3-} Alanine

R = H- Glycine

R = HO – CH_2 CH_2 Serine

R = HS - CH_2 Cystein

R = CH_2- Phenyl Alanine

R = CH2 S - CH2 - CH2 Methionine

R = CH_3

R = CH_2

CH _____ Valine

CH_3 Tryptophan

Nucleic acids: The DNA i.e. Deoxyribonuleic acid and RNA Ribonucleic acids. These are the nucleic acids and are made from building units called nucleotides. Nucleotides are phosphoric acid esters of neucleosides.

A neucheoside is composed of sugar (Ribose or Deoxyribose) + Nitrogen Bases (purine or pyrimidine) sugar.

Nucleic acids are found as components of the chromosomes, mitochondria and chloroplasts. The Neucleotides are therefore

Sugar + Nitrogen bases + Phosphate group

(Purine or pyrimidine): the Nitrogen group of bases are either purines or pyrimidines. Purines include Adenine and Guanine while pyrimidines include unracil, thymine and cytosine.

Diagram

The lipids

These are water insoluble organic substances found in cells. They are soluble in chloroform, ether, and benzene. There are different classes of lipids including:

a. Neutral fats (fats and oils) (b) Phosphoglycerides (c) Sphingolipids and Glycolipids (d) waxes (e) steroids (f) terpenes

Functions of lipids include the followings:

- as structural components of membranes
- as storage depots of metabolic fuel
- as transport form of metabolic fuel
- as protective components of the cell walls of many bacteria, leaves of higher plants, exoskeleton of insects and skin of vertebrates
- some lipids include some vitamins and hormones

The building units of most lipids include the fatty acids and glycerols etc. for example Neutral fats (or Acylglycerols or fats and oils or glycerides) are fatty acid esters of the alcohol called glycerol.

Glycerol CH_2OH is a trihydric alcohol i.e. with 3 – OH groups

HCOH

CH_2OH

CH_2OH

The fatty acids found in fats and other lipids are of different types based on the number of carbon and double or triple bonds in their structure.

Some fatty acids:

a. saturated types

$CH_3(CH_2)_{10}COOH$ - Lauric acid

$CH_3(CH_2)_{12}COOH$ - Myristic acid

CH2(CH2)12COOH - Palmitic acid

CH3(CH2)16COOH - Stearic acid

CH3(CH12)18COOH - Arachidic acid

b. Unsaturated types

CH3(CH2)C = CH(CH2)7COOH - Oleic acid

CH3(CH2)4CH = CHCH2 = CH(CH2)7COOH - Linoleic acid

UPTAKE OF NUTRIENTS (ABSORPTION AND CONDUCTION)

Green plants absorb water and inorganic salts passively from the soil by the unicellular root-hairs. Absorption is also actively carried out by the roots. Small quantities of various soluble inorganic salts such as nitrates chlorides, sulphates, phosphates etc. dissolved in soil water are absorbed in a state of very dilute solution. However absorbtion of salts and water are independent of each other and they are not. The mineral salts absorbed undergo extensive ionization. The ionized particles of such salts are taken up by the cells where they accumulate sometimes in heavy concentration. The ions may travel and as such they combine into suitable compounds. Although some compounds are passed through the plasmamembrane by diffusion. The fact that the ions of some salts are higher in concentration in the cell sap and yet more ions are still added shows that some active transport against the concentration gradient is going on.

Therefore ions of mineral salts are either absorb ACTIVELY OR PASSIVELY.

Passive absorption is physical and non-metabolic i.e. it doesn't need the expenditure of ATP or cellular energy. Ions may move upwards through