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 $3^{o}C$ 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.

i. 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 the transpiration current along with the mass flow of water. Transpiration may help in the absorption of ions through the transpiration pull. Active absorption: This is dependent on cellular enrgy (ATP).

ii. This is the principal method of salt absorption. The idea that the cell membrane is impermeable to exchange of free ions has lead to the conception of a specific Carrier Mechanism to explain this active transport. It is assumed that a Carrier Molecule (probably a phospholipid called lecithin) picks up ions from the outer part of the membrane, into the inner part. The carrier moves in one direction and hence ions carried in cannot be leached and washed out and therefore cannot be exchanged for those in the external solution. The carrier method has been found to be dependent on ATP especially from oxidation of glucose molecules. Absorption of salts depends on a number of conditions including aerobic root respiration, light intensity, rate of transpiration, permeability of cell membrane, temperature, pH.

SOME CYCLES OF RAW MATERIALS IN NATURE

Chemicals substances are utilized by plants; animal utilize plants and some of the raw chemical, both excrete unwanted materials, both die and their remains are subjected to the decaying action of micro-organism, thus, the raw materials are put back into circulation again. There is thus, for all these raw materials, a broad cycle of absorption utilization, and ultimate return to the raw material status again.

Diagram

CHEMOSYNTHESIS:

Chemosynthesis involve the transformation of one kind of chemical energy (and not light energy) to another.

Colourless autotrophic bacteria are able to synthesize carbohydrate without chlorophyll and therefore, without light as a source of energy. Their bacteria are aerobic, and the energy required for the metabolic process is derived from the oxidation of certain inorganic compounds present in their environment. The energy released by this oxidation process is used to convert CO_2 through several intermediate reactions to carbohydrate and other organic compounds, such as proteins, fats, etc.

Chemosynthetic bacteria do not use water (H_2O) either as the 'donor' of hydrogen to reduce CO_2, as in normal photosynthesis and therefore, no liberation of oxygen take place in the process. Common chemosynthesis bacteria are sulphur bacteria, iron bacteria and nitrifying bacteria. Sulphur bacteria synthesise organic compounds from CO_2, using energy derived from oxidation of hydrogen sulphide (H_2S). Sulphur is deposited in the bacterial cells. Iron bacteria obtain the energy needed for chemosynthesis by the oxidation of ferrous hydroxide to ferric hydroxide. The two groups of Nitrifying bacteria transform ammonia (NH_3) during the process of protein decay in soil, first into Nitrites by nitrisomonas.

$2NH_3 + 3O_3 \qquad 2HNO_2 + 2H_2O + Cal$

and then into nitrates by Nitrobacter $2\ HNO_2 + O_2 \qquad 2HNO_3 + 21.6\ Cal$. The energy thus liberated by the oxidation of ammonia is used to make their own metabolic products.

PHOTOSYNTHESIS

Photosynthesis consist of the manufacture of simple carbohydrates such as sugars in the green leaves by the chlorophyll (in the chloroplasts) in the presence of sunlight (as a source of energy) from carbondioxide and water absorbed from the air and the soil. The process is accompanied by liberation of oxygen. By this process considerable amount of radiant energy is transformed by green cells into chemical energy and stored in the organic substances formed. Since glucose or fructose appears to be the first carbohydrates formed in photosynthesis he overall equation may be represented as

$6CO_2 + 12H_2O \qquad C_6H_{12}O_6 + 6H_2O + 6O_2$

The mechanism of photosynthesis is completed in two stages or phases i.e. the light and dark phases. The light (Hill reaction) phase involves a series of chemical reaction of which light is indispensable and therefore called light reaction. This involves absorption of light energy by chlorophyll, splitting of water molecules with the production of reducing agent (NADP) and some cellular energy. The dark phase which does not need light, is a series of chemical reaction of CO_2 (fixation of carbondioxide) by the reducing agent (got from light phase) to organic compounds.

Diagram (Carbon cycle)

ESSENTIAL OF LIGHT REACTION

- Chlorophyll pigment (in the grana of chloroplast) absorbed light energy (quanta) from sunlight and becomes activated or excited.
- The extra energy stored in the chlorophyll now goes to break up water molecules (proteolysis of water) to give energized electrons and oxygen.
- There are two light trapping sites or photosystems each with its own electron acceptors in the chloroplast.
- High energy or excited electrons are passed from photosynthesis II through its electron acceptor to the cytochrome or photosynthetic electron-transport chain.
- Energy of the electron is used to synthesize a molecule of ATP or cellular energy at a site on the cytochrome chain. This is known as Photophosphorylation.
- Electrons passed down the cytochrome chain are re-energised by more radiant energy absorbed in photosystem I.
- The excited or energized electrons are accepted by the electron acceptor of photosystem I and are eventually used to reduce NADP to NADPH a reducing factor or agent needed in the next phase of photosynthesis.
- However at times one more ATP molecules when re-energised electron are passed from the electron acceptor of photosystem I back to the

cytochrome chain. The synthesis of ATP as a result of this cyclic transport of electron is called cyclic photophosphorylation.

- The product of the light phase include ATP (cellular energy) and NADPH a reducing factor. These are needed in the next phase of photosynthesis (i.e. Dark phase).

Diagram

Chlorophyll

Molecules

nH_2O nH+ + n(OH)-

n(OH)- + n(OH) $nH_2O + nO_2$

2H 2e- + 2H+

Diagram

ESSENTIALS OF DARK REACTION

i. All reduction steps from CO_2 to sugar are dark reactions.

ii. A 5c compound, ribulose-P is activated by ATP forming Ribulose-di-P also a 5c compound.

iii. The (5C) RUDP combines with CO_2 to form an unstable 6C complex.

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

v. Many of the remaining portion of the splitting complex is used to reform ribulose phosphate which fed into the chain of reactions to maintain the continuity of the process.

vi. There is further activation of phosphoglyceric acid to diphosphoglyceric acid using ATP.

vii. Phosphoglyceric acid is reduced to phospholyceraldehyde using the reducing factor NADPH.

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

ix. The various step in the dark phase or calvin cycle is catalysed by many enzymes.

DARK PHASE OF PHOTOSYNTHESIS (diagram)

OTHER ORGANIC SUBSTANCES SYNTHESIZED

The other organic compounds synthesized are amino acids, proteins, fats and oils etc. about 20 amino acids are known to be constituents of especially plants proteins. Amino acid are synthesized in the green leaves and in roots. There is experimental proof that the reduction of nitrate to ammonia and synthesis of amino acids usually takes place in the green leaf in the presence of light. The synthesis of amino acids is correlated with photosynthesis which supplies necessary carbon, hydrogen and oxygen. Most amino acids are formed through trans amination which involves transfer of amino group (NH_2) from some organic compounds e.g. glutamic acid to the carboxyl group (-COOH) of any of the keto-acids. The group of enzymes catalyzing this reaction is called trans aminases. Some amino acids include Alanine, Glycine Leucine, aspartic acid, glutamic acid, cystine, tyrosine, etc. amino acids are the precursors of proteins. The proteins synthesis depends on the codes from the sequence of basis in DNA in the nucleus transferred to the structure of the RNAs.

Fats and oils are lipids (fatty) substances formed in the living cells of both plants and animals. They are composed of carbon hydrogen and oxygen. Oxygen occurs in low percentage. Fats and oils are made from glycerol and fatty acids by condensation. Fats and oils have been known to be formed from carbohydrates.

Respiration (Diagram)

Respiration is essentially a process of oxidation of organic compounds especially simple carbohydrate such as glucose in the living cell with the release of energy in form of ATP. The important feature of the oxidative process is that the potential energy store in organic compounds in the living cell is released stepwisely in the form of kinetic energy under the influence of a series of enzymes.

The energy produced is made available to the living cell for its metabolic activities other stored food materials such as fats, proteins and other carbohydrates can be used in the absence of glucose. These are first hydrolyzed and then oxidized.

The oxidation of glucose may be (i) complete as in Aerobes (i.e. living organisms that take in oxygen) with the formation of O_2, water and energy. This is shown by the equation

$C_6H_{12}O_6$ + $6O_2$ $6CO_2$ + $6H_2O$ + 38 ATP. The oxidation may also be incomplete as in some anaerobes (living organism) that does not utilize oxygen e.g. bacteria, yeast etc. with the formation of ethyl alcohol or some organic acids (e.g. lactic acid) and CO_2 as shown by the equations

(a) $C_6H_{12}O_6$ $2C_2H_5OH + 2CO_2$ + 2 ATP

Fermentation

(b) $C_6H_{12}O_6$ $2CH_2CHOHCOOH + 2H_2O$ + 2 ATP

There are three phases or stages to the complete oxidation of a molecule of glucose to carbondioxide water and 38 ATP molecules. The first phase is glycolytic and it takes place in he absence of oxygen. The second phase which is the complete oxidation of pyruvic acid formed (from the first phase) to CO_2 and H_2O is called the kreb's cycle. The third phase is electron transport chains in which the high energy electrons of the hydrogen removed are fed to produce cellular energy or ATP at different points.

Phase 1 (Anaerobic or Glycolytic phase)

Glucose is first phosphorylated by ATP. The phosphorylated glucose molecule is stepwisely broken to two molecules of phosphoglyceric acid a 3-carbon compound and finally 2 molecules of pyruvic acid a key 3-carbon compound. Other common reserve materials used starch, glycogen, sucrose, maltose. Each is however first hydrolysed to glucose.

It is to be noted that the fate of pyruvic acid depends on the type of cell. In yeast it is converted to ethanol and CO_2 while in some bacteria or tired muscle cells it is converted to lactic acid and H_2O.

Phase II (Aerobic phase, Kreb's cycle)

With the presence of oxygen the pyruvic acid ($C_3H_4O_3$) undergoes oxidative decarboxylation to form Acetyl-Co enzyme A in a series of steps catalysed by some enzymes. The Acetyl-Cp A (C_2H_3O CoA) is a connecting link between the Anaerobic phase and the anaerobic phase or kreb's cycle of respiration. Kreb's cycle consist of series of enzyme catalysed chemical reactions under aerobic conditions proceeding in a cycling manner. The cycle is also called citric acid or tricarboxylic acid cycle. This is because most of the organic acids in the circle (the Chief of which is citric acid) have three carboxyl groups COOH within their structures.

Acetyl Co A enters the cycle by reacting with oxaloacetic acid (with co-enzyme A part been released) to form citric acid etc. Apart from the release of CO2, there is also stepwise removal of a total of 12 hydrogen atoms passed on to 12 hydrogen, acceptors or NAD to form 12 NADH now a reducing agent.

Phase III (Electron transport of cytochrome chain)

All the powerful electrons removed (usually accompanied by removal of hydrogen to give 12 NADH) are fed into an oxidation reduction system in the mitochondrion. This is where the energy still stored in electrons energy. Therefore the metabolic pathway through which the electrons pass from one compound to another is called electron transport or cytochrome system. In respiration, it consists of commonly of NAD (Nicotinamide Adenine di nucleotide), FAD (Flavin Adenine di nucleotide), Co-enzyme and the cytochromes b, c, a (cytochromes and pigmented bodies with ion in their structure). The ATP molecules are produced at three points along this chain for every 2e or NADH, molecule passed alogn it. At each of these point ATP is usually formed from addition of an inorganic phosphate to ADP i.e. ADP + P ATP.

It is to be noted that phosphorylation of ADP in the mitochondrion at the expense of chemical energy oxidation reduction reactions of the electron transport system is called oxidative phosphorylation. With the reduction of the cytochromes, the electrons pass down to oxygen and the 'activated' oxygen freely combines with hydrogen (now released to the cytoplasm from the mitochondrion) to form water (H_2O).

ELIMINATION OF WASTE MATERIALS OR PRODUCTS AND METHODS IN PLANT AND ANIMALS

The term excretion can be applied only to a process which eliminates substances which have been taken up by cells or have been formed as a result of their activities. Excretory products are of numerous different kinds and they vary from species to species, and even from time to time in the same organism according to the food supply and the condition. They may be taken in as foods, or with foods but not required as such. They may be products of cellular decomposition, or substances formed as a result of normal metabolic processes, or the result of some disease condition. Animal faeces are largely compound of materials which have never been part of the cellular constituents of the body. Faeces are eliminated or ejected from the gut through peristaltic movement of the muscles of the elementary canal. In most animals there exist special body system for elimination of waste materials. However in plants there are none.

Excretory methods and products in plants

There are no specialized excretory organs or systems in plants. Unwanted metabolites may be secreted into intra or intercellular spaces. The aerating system of the plant makes possible the ready diffusion of respiratory CO_2 into the surrounding water or atmosphere. Parts of plants such as leaves branches, seeds and fruits may be shed and carry with them accumulations of unnecessary substances. However such elimination is purely secondary to the true purpose of leaf fall and seed and fruit dispersal.

Excretory products in plants may include Calcium salts of organic acids oxalic acid, calcium oxalate crystals, some metallic ions. Leaf abscission can regularly aid removal of metallic ions such as excess calcium, iron, manganese and silica, from plants, Brazil nuts sometimes contain large quantities of barium, and the walls of some fungi show the presence of barium sulphate. Aluminium oxide may make up as 30-80% of Australian oak. Many alkaloids are physiologically an important by products of nitrogen metabolism of the plant species in which they are found. Such alkaloids are deposited in plant parts such as Bark leaves, flowers, fruits, seeds. The alkaloids include: nitocine from tobacco leaves, quinine from the bark of cinchona tree, morphine from the fruits of poppy plant, strychnine and brucine from strychnos plant, Atrophine from the deadly night shade (Atropa) and colchicine from the meadow safon. The listed alkaloids are useful in medicine.

Simplified Scheme representing Aerobic and Anaerobic respiration (Diagram)

Excretory Methods and Products in Animals

Excess protein and other nitrogen containing compounds such as the purine and pyrimidine bases of nucleic acids are potential sources of danger. The processes involved in making part of these molecules useful e.g. conversion to carbohydrate results information of toxic nitrogenous compounds which must be eliminated of such compounds is Ammonia (NH_3). In unicellular organisms e.g. the protozoans especially those bathed in fluid medium continuously, NH_3 being soluble may diffuse into the surrounding fluid medium in an unchanged state. The animals (invertebrate) which do this are described as AMMONOTELIC where the organism is large and free diffusion from its surface is impossible the NH3 is converted to non-harmful substances as urea, uric acid etc. Hence some animals are described as either URECTELIC or URICOTELIC. Ureotelic animals are able to form urea from ammonia while the uricotelic ones form uric acid from ammonia. Urecotelic animals include birds, terrestrial reptiles and some insects.

An examination of excreted matter shows the presence of other nitrogenous compounds in many instances. These include hippuric acid and ornithuric acid which are formed from benzoic acid in the diet. A creatinine and creatinine are also found in muscle. Excreted nitrogenous pigments resulting from the breakdown of haemoglobin are the orange-red bilirubin and the green product derived from uric acid. Allanto acid is derived from oxidation of allantoin.

Excretory methods in animals

	Method/Structure	Animals
1.	By diffusing from cell surfaces	protozoa, sponges, coelenterates
2.	Through contractile vacuole	protozoa
3.	By flame – cell system	flatworms
4.	By solenocyte cells	amphioxus
5.	By nephridium system	Coelomate Animals such as earthworms, round worms, mollusks, crustaceans
6.	By green gland (modified Nepridum)	Astacus (cray fish)
7.	By Malphigian tubules	Insects, spiders
8.	By Kidney	Vertebrates e.g. fishes, reptiles, birds, mammals

primarily, all the systems of animals concerned with excretion of nitrogenous substances employ the same principle. They involve surface through which unwanted materials can be passed directly or indirectly to the outside complexity of the system increased with complexity of the body in

ASEXUAL REPRODUCTION

Cells are the basic structural and functional unit of organisms. Cells contain in nucleus in the cytoplasm. The nucleus controls all cellular activities. Living things have the ability to reproduce their kind, for the survival of the specie. There are two methods of reproduction

(1) Sexual reproduction in the production of new individuals with a combination of the hereditary information of two different cells i.e. gametes

(2) Asexual reproduction that is the formation of offspring without the union of gametes.

The following are the different types of asexual reproduction:

(a) Fission: This is most common among unicellular organisms. They divide into two roughly equal halves and grow to full size. The process is continuously repeated. Amoeba does it every 20-30 minutes. Merozoites of plasmodium exhibit multiple fission known as schizogony.

(b) Budeding: This is similar to fission but the parts are not equal e.g. yeast. A projection or bud develops at a portion of cell wall. The nucleus divides and one passes into buds. The bud can also bud before separating from parent. In hydra (multicellular), a projection of many cells from grows develop, tentacles and other adult features before pinching off. The tapeworm buds off mature proglottides. Rhizomes and stolon are found among plants. Miniature leaves are found in the margin of Bryophyllum.

(c) Sporulation: Formation of small bodies with nucleus and small cytoplasms. Terrestrial organisms have small and light spores with protective wall for easy dispersal the resistant wall keeps spores in protected and dormant state in unfavourable periods. Some bacteria are spore formers. In chlamydomonas, the cell content divides 1-3% to give 2 to 8 zaoospores, each with a nucleus and 2 flagella. Each grows to become adult. The fungi are prolific spore producers. The mosses, club mosses and ferns use spores to disperse.

(d) Fragmentation: The organisms breaks up into several parts. Each then regenerates all features of mature organism. Some annelids break into 8 or 9 parts which grow into adult. Fragmentation usually depends on external forces e.g. waves break up green and brown algae at sea shore spirogyra breaks to regenerate fragment lost. Man makes cuttings of plants to produce more.

In all forms of asexual reproduction, new cells (exact copies) are produced. The cells retain the hereditary blueprints of the parents. The blueprints are found in the nucleus residing on the chromosomes. They are distributed to daughter cells through the process of mitosis. Chromosomes are tenuous when not dividing (interphase) and are known as chromatins. They are active in RNA synthesis and shortly before mitosis, DNA systhesis. Mitosis is divided into 4 stages.

Prophase: The nucleolus disappear and chromosomes appear. The nuclear membrane disappears. Chromosomes coil up, becomes shorter and thicker. They appear double and joined at the centromere.

Metaphase: The spindle fibres extens between the poles of the cell attaching to individual centromeres. The centromeres arrange exactly on the equatorial plate.

Anaphase: Centromeres duplicate, separate and move to opposite poles.

Telophase: Chromosomes are at the poles, uncoil and coalesce. Nucleolus appear, nuclear membrane also. The cell plate appears at the equator and gradually a cell wall is secreted in plants. In animals, a furrow in the cell membrane forms at the equator to divide the cell.

(diagram)

The union of the two gametes (fertilization) in sexual reproduction results in new individuals. The gametes could appear similar, e.g. isogametes of Chlamydomonas. Individual chlamydomonas cells divide 4 or 5 to give 16 to 34 isogametes. The cell wall breaks to release them and these fuse with the gametes of another cell to form a zygospore.

In most organisms, sperm i.e. the male gametes, are tiny consisting of little more than a nucleus and flagellum (which is used for movement to make contact with the egg). The female gamete, the egg, is larger and non motile with substantial quantities of cytoplasm for the developing embryo. Such gametes are said to be heterogametes. Fertilization of heterogametes gives zygote i.e. a fertilized egg. These involve 2 individuals combining to give new characteristics.

In hermaphrodites, both male and female gametes are produced by one individual e.g. Hydra, earthworm and most flowering plants. Usually two individuals are involved in producing the zygote. This promotes variability. A good example is found in Escherichia coli E. grows will in the presence of glucose and some inorganic salts. Some mutagenically treated ones (ultraviolet irradiation) are known. One strain is deficient in the ability to synthesize vitamin B, Biotin and amino acid. Methionine: Another strain produces the above but not the B vitamin; thiamine and amino acids; threomine and leucine. The two strains require the deficient substances to grow. But if both are mixed and plated on a medium colonies develop and survive even in the absence of the vitamins and amino acids their parents require to grow. This shows the simplest form of creation of variability. The mechanisms is not clear but in higher organisms the process of meiosis is implicated.

Meiosis: Each somatic cell of the species of organism contains diploid or 2^{nd} number of chromosomes representing the homologous pairs. If cells with diploid chromosomes were to serve as gametes, zygotes will have double the number of the parents. Meiosis corrects this by reducing the chromosome number in cells become gametes (germ cells) to half. It goes by duplicating an homologous pair and then separating into four daughter cells each with the haploid number of chromosomes. So that a zygote will have the 2[nd] number.

1[st] Meiotic Division: Prephase is slower and shorter synapsis occurs in each homologous paid and an exchange of parts between the members.

Metaphase: Centromeres of homologous pair are arranged on the equatorial plate and attached to the spindle.

Anaphase: Each centromere moves towards opposite poles. No duplication of members ocfcurs.

Telephase: Two daughter cells with a member of each homologous pair of chromosomes.2[nd] Meiotic Division: Starts immediately or a little after 1 meoisis.

Prophase: Each chromosome is still a doublet with non-identical members.

Metaphase: Each chromosomes moves to the equatorial plate, attached to the spindle. They are duplicated.

Anaphase: Daughter chromosomes separate and move towards poles.

Telephase: Chromosomes are at the poles. Four daughter cells are produced with one member of a pair of chromosomes i.e. haploid. There are two cells with chromosomes of either of the parents and two with chromosomes containing both maternal and paternal parts.

When n = 2 we have 2 different combination (2^1)

n = 4 we have 16 different combinations (2^+) etc.

This random assortment coupled with crossing over, makes total similarly between two individuals quite different.

Meiosis reduces chromosome number and creates variability, even between two gametes of same individual.

Asexual reproduction produces offspring like parents while sexual reproduction produces variant offspring.

GAMETOGENESIS OR GAMETE FORMATION

Spermatogenesis:

Sperm cells or spermatogenia are produced by specialized cell in the gonads or testis. These are developed from the primordial germ cells which are diploid. Spermatogenia may divide to produce more or be transformed into primary spermtocytes after some growth. 1^{st} meiotic division follows to give secondary spermatocytes 2^{nd} meiotic division occurs to give spermatids. Each spermatid differentiates into a spermatozoon with almost all cytoplasm lost.

Oogenesis

Eggs are produced in the ovaries. A primordial germ cell gives mitotically many oogonia. In aquatic organisms, division is once a year. In reptiles, birds and mammals, it stops long before birth. In human foetus, by 15 weeks, oogonia production is almost completed. Only one oogonial cell grow into a primary cocyte, surrounded by a layer of cell sin follicle. The others degenerate. At puberty, one egg (ovum) is released monthly. After release as primary cocyte, it undergoes 1^{st} meiotic division. Secondary oocyte and small polar body are produced. The second meiotic division of the secondary cocyte gives the only functional egg (plus another polar body).

GAMETOGENESIS IN PLANTS

In plants, we have the sporophyte and the gametophyte generation. In angiosperms, the sporophyte is the dominant one while the gametophyte is greatly reduced in size. The male gametophytes are called microgametophyte while the females are megagametophyte. The males are found in the anther while the megagametophyte are in the ovary. The anther contains the pollen mother cell called microsporocytes which are diploid. Each undergoes meiosis I and II to give rise to four microspores which are haploid. Each spore nucleus undergoes metotic division without cytokinesis. One is the generative nucleus and the tube nucleus. This cell develops into pollen grains i.e. miucrogametophyte. After the pollen grain is placed on the stigma, the nuclei move into the pollen tube where the generative divides into 2 nuclei mitotically.

Megasporogenesis

Each ovule in plant contains the diploid megaspore mother cell or megasporocyte. The megasporocyte undergoes meiosis to give rise to 4-celled megaspores which are arranged in a linear order. Three of these degenerates leaving one which eventually becomes the megagametophyte. The nucleus undergoes 3 successive mitotic divisions without cytokinesis to give a cell with 8 haploid nuclei. The cell is the embryo sac. Three of the 8 nuclei migrate to the chalaza and of the embryo sac (opposite to the opening 0 micropyle) and 3 to the micropylar end. The middle nuclei of the 3 at micropylar end becomes the functional egg and the two the synergids. Those at the chalaza end are called antipodal cells. They usually degenerate. The two at the centre are the polar nuclei. One of the two nuclei from the generative fuses with the egg and the other fuses with the remaining two cells to form the triploid endosperm.

GROWTH AND DEVELOPMENT

Growth is the 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.

During growth, the amount of cytoplasm generally increases, causing an increase in length, volume, area or weight of the organism.

Closely linked with growth is the process of development of an organism when cells differentiated into tissues and organs. Plants in their development may form seeds which germinate and show primary growth into roots, stems, leaves and flowers. Some plants may show secondary growth in trees. Animal development may show profound changes called metamorphosis seen in insects and amphibians. The overall growth of multicellular organisms is achieved by increase in the number of body cells as a result of cell division, this is accompanied by increase in size of individual cells by cell growth. When the rate of anabolism is greater than the rate of catabolism, the organism will show growth. When catabolism exceeds anabolism the organism will show a decrease in size and ultimately dies.

Patterns of growth in living organisms

The growth curve: Growth of both individuals and whpole populations tend to follow a sigmoid curve. This is one that starts slowly then increases to a maximum rate and then reaches an asymptote where no further change occurs. This curve can be interpreted mathematically by assuming that the rate of growth at any time is proportional to the difference between the present weight and the final weight that will be attained. In the case of the growth of an individual the first phase is marked by an increase in cell numbers but not necessarily in whole size. The next phase is called the grand period of growth and here rapid increase in weight of the whole organism occurs. As maturity is reached the growth rate tails off and equilibrium is reached. The final stage of senescence is marked by decrease in weight as breakdown exceeds growth and this terminates in death.

In the case of many plants (especially annuals) e.g. maize there is a sharp decrease in weight following the production of seeds and flowers. This is also true of fishes such as the plaice and salmon.

Growth and form

Growth of many marine organisms such as lobsters and seaweeds tends to be unlimited and the organism continues to grow until its death. In land living species the more demanding nature of the environment produces a limited form of growth and increase of size ceases at a certain stage. Tree growth is theoretically unlimited (trees of at least 2000 years of age are known).

Metamorphosis

The fertilized eggs of most animals develop into an embryo which later grows into an adult. Other animals, amphibians and certain insects demonstrate considerable changes in body form between the fertilized egg and adult. Metamorphosis is the changes in body form of a larva or immature organism into an adult e.g. tadpole to frog and caterpillar to butterfly.

Incomplete metamorphosis

		Ecdysis	
Egg	nymph		adult
	Sexually	moulting	
	Immature		
	Lack wings	stages called instars	

After the last moult is becomes sexually matured e.g. Locust, cochroaches

Complete metamorphosis

Housefly, moth, butterfly, mosquite, honey bees

Egg active larva pupa adult

Frog metamorphosis

A free tadpole larva emerges from the fertilized egg, attaching itself to a pond weed. It feeds on yolk food reserve and respire by external gills.

-A moth develops, allowing the free-swimming tadpole. Internal gills protected within an operculum cover replace external gills.

-Hindlimbs appear followed by forelimbs and the gills are replaced by lungs feeding halted whilst the tail is absorbed and a mouth and tongue develop, allowing a carnivorous diet to replace the herbivorous earlier diet.

Dormancy

A resting condition with a very low rate of metabolism in which growth ceases. Seen in seeds spores, buds, fruits and perennating organs such as bulbs, corms and tubers.

Dormancy is the means to survive adverse conditions of low temperature, lack of moisture in drought and watery conditions. Seeds may have variable dormancy periods lasting from one up to 100 years. Insects show a type of dormancy, eggs of human fleas remain dormant in floor board crevices, butterfly pupa hang dormant under ledges and adult houseflies cluster together in winter time in attic spaces. Amoeba encysts in time of drought and extremes of temperature.

Hibernation is a type of dormancy found in many different animals and is a means of survival over winter.

Growth regions

Plant

There are 3 main growth regions in flowering plants

(i) Cell division

(ii) Cell elongation

(iii) Cell differentiation region

Animals

The fertilized egg nucleus undergoes repeated mitosis to produce a mass of undifferentiated cells called a blastula. The cells differentiate and move into 3 main groups through a process called gastrulation

(1) endoderm future gut

(2) mesoderm future muscle and blood

(3) ectoderm future skin and nervous system

insects show intermittent growth in shedding the chitinous exoskeleton by ecdysis. Mammals including man demonstrate a type of growth where different body parts grow at different rates from the overall body growth rate. The human brain and eye grow more slowly than the arms and legs.

Growth measurement

(1) total fresh weight growth can be defined as the permanent increase in biomass, cell numbers or body size as a result of anabolic synthesis, cell division and cell expansion.

(2) Dry weight growth of an individual organism can be measured by the following methods

(3) Volume overflow can

(4) Photographs time lapse photography graphically growth in plants

Growth factors

(a) Genes

(b) Nutrition

(c) Chemicals and drugs carcinogenic chemicals e.g. tobacco tars, - cause cells to divide haphardly or produce neoplasms or cancer tumours in mammals. Antimitotic drugs slow down mitosis of cell nuclei and are used in treatment of cancer neoplasms. Thalidomide caused malformation of limbs in human embryos, hindering their normal growth due to the drugs teratogenic or malforming effect.

(d) Light: Plants in shade or darkness grow tall and overcrowded plants tend to seek better positions facing the light. Mammals may be affected by not being able to form vitamin 'D in the skin resulting in abnormal growth or rickets in the young.

Enzymes Properties, Composition, types, mechanism of action

Classification

Enzayme are biological catalyst which accelerate or decelerate chemical reactions in living cells. They differ from inorganic catalysts because of their specificity and their not been able to withstand high temperature (50oC).

Enzymes are proteinous in nature and sometimes the proteins have non-protein parts attached to them. If the attachment between the protein and non-protein parts of an enzyme is tightly bonded by covalent bond; the non-protein part is called a prosthein group, examples being metals, like Cu, Mg, Fe. If the attachment between the protein and non-protein parts of an enzyme is loosely bonded by hydrogen bond, the non-protein part is called a co-enzyme or co-factor, examples being vitamins. The co-enzymes and prosthetic groups may become attached to several different proteins, thereby forming different enzymes. Enzymes was first discovered in the 19th century by Edward Buchner when he found yeast turning sugar into alcohol.

Properties (Characteriscs) of enzymes

a. Enzymes are active in small amounts i.e. only a small amount of enzyme is necessary to convert a large amount of substrate into product. The same substrate could be utilized by different enzymes e.g.

Phosphate hexose

Fructose -6- Phosphate — Isomerase — Glucose-6-phosphate (substrate)

Phosphogluco mutase — glucose-6-phosphate dehydrogenase

Glucose-1-phosphate — 6-phosphoglucolactone

b. The same enzyme could act on different chemical reactions e.g.

Sucrose + Inorganic Phosphate	Sucrose gluycosyl transferease	B-D-glucose-1-phosphate +
Sucrose + L-sorbose (monosaccharide)	sucrose glucose transferease	glucose-sorboside + Fructose

c. Enzymes work at narrow range of temperature. Optimum temperature for their working is $40^{o}C$ and they become denatured (killed) at $60^{o}C$.

d. Enzymes work at specific pH. Most function around neutral pH (pH 5-7). However, pepsin (found in stomach) works at pH 2-3 and trypsin (found in the duodenum) works at pH 8.5

e. Atalytic actions of enzymes may be specific. Thus an enzyme which catalyses one-reaction may not catalyse another e.g.

i. invertase works only on sucrose

sucrose invertase glucose + fructose

1. amylase works only on starch

   starch amylase maltose

2. Maltase works only on maltose

   Maltose maltase glucose

3. zymase works only on glucose

   Glucose zymase CO_2+ethanol

1. Enzymes are not destroyed by the reactions they catalyzed and could therefore be used and used again.
2. Enzymes could be poisoned by chemical compounds like mercury chloride (HgCl2), silver chloride (AgCl2) and hydrogen cyanide (HCN).These inactivate the enzymes for example HCN blocks the enzymes involve in respiration.

Mechanism of action (working) of enzymes

This is explained by two hypotheses

1. Chemical hypothesis

   A B

Chemically, energy needed could be inform of heat (temperature) to activate passive A by bombarding A's molecules so that they could become activated and later turned into B's molecules.

The energy above average that is required A molecules to react and be converted into B molecules is the activation energy of the reaction.

Enzymes are believed to catalyze reaction by lowering the activation energy.

E.g. in

2H2O2 catalase 2H2O+2O2

The activation energy in the absence of catalase is 18,000 cal/mol while in the presence of catalase, it is 6,400 cal/mol.

ii. Lock and Key hypothesis: The enzymes is believed to be the padlock and substrate the key. Enzymes (the padlock have active centres which must fit the substrate (the key) before chemical reaction could take place.

(Diagram)

Classification of enzymes

Enzymes are generally of 2 types, namely

i. Intracellular enzymes (enzymes working inside the cell).

ii. Extracellular enzymes (enzymes working outside the cell).

Enzymes are classified as follows;

1. According to substrate they act upon: Examples are arginase which acts on arginine, tryrosinase which acts on tyrosine, lipase which acts on lipids, proteinases which acts on proteins and carbohydrases which acts on carbohydrates and maltase which acts on maltose.

2. According to the type of reactions they catalyse: Examples are hydrolyses (hydrolytic enzymes), oxidases (oxidation reaction enzymes), phosphorylases (phosphate adding and deleting enzymes). In both cases above, the suffix ase or in is added to the name of the substrate or reaction type.

Specific enzymes types

i. Hydrolyses(hydrolytic enzymes)

These catalyse the addition of the elements of water to specific bond of the substrate

RCO – OR HOH RCOOH + R`OH

e.g. lipases, carbohydrates, proteases.

ii. Oxidases (oxidation reduction enzymes)

these catalyse the removal or addition of hydrogen, oxygen or electrons from or to the substrate, which is thereby oxidized or reduced in the process.

$RH + HA$ $R + AH_2$ (removal of H_2)

$RO + ½O_2$ RO_2 (addition of O_2)

R^{2+} R^{3+} + e- (removal of electron)

e.g. dhydrogenases and oxidases.

iii. Phosphorylase

these catalyse the addition or removal of elements of phosphoric acids e.g. glucose + phosphate

Hexokinase glucose 1 phosphate

iv.Carboxylase: These catalyse the removal or addition of CO_2 e.g.

Ribulose 1, 5-diphosphate Carboxydismutase Ketoacid

(5C) (6C)

v. Isomeraes: These carry out breaking of double bonds e.g. lysozyme (found in tears, nasal mucus and egg) which dissolves certain air-borne cocci (bacteria) by breaking the double bonds of the polysaccharides in their walls.

Estimation of rates of enzyme activities

i. Use of turnover number: This is the number of moles of substrate converted per minute by 1 mole of enzyme. Succinic dehydrogenase has turnover number of 1150 while carbonic anhydrase has turnover number of 36,000,000.

ii. Manometric gases evolved as a result of enzyme activities are measured manometrically e.g oxidase, caboxylaes

iii. Spectrophotometric uses that fact that the different quantities of product have different optical density at the same wavelength. The wavelength used depends on the enzymes type involved e.g. for amylase, the wavelength is 490nm and for proteases it is 700nm

iv. Coloration method: works on the basis that the substrate and product have different colours with a known dye. The disappearance of the colour with time is taken note of e.g.

Starch + iodine + E (blue-black colour)

Amylase

Maltose + iodine + E (iodine colour)

v. Chemical estimation: This involves titration, chromatography and electrophoresis techniques. E.g. lipases are estimated by breaking lipids into fatty acids and glycerolusing lipases and the liberated fatty acids quantities determined using titration with NaOH and phenolphthalein as an indicator.

Units of enzyme activities are mg product/ml/min, mg product/min/mg protein e.g. maltose

Maltase glucose

Enzymes Inhibitors

These are compounds which prevent, limit or stop enzymes activities. They ae divided into competitive inhibitors and non-competitive inhibitors.

i. Competitive inhibitors have similar shape to the substrate and can therefore fit into the active centres of the enzymes. The lower enzymes activities e.g. the inhibition by malonic acid of the enzymes succinic dehydrogenase which catalyses the conversion of succinic acid into fumaric acid.

COOH

H-C-H

H-C-H + Enzyme Fumaric + Enzyme

COOH acid

Succinic acid

COOH

H-C-H + enzyme no reaction

COOH

Maltonic acid

Competition inhibition could be overcome by increasing the concentration of the substrate

ii. Non-competitive inhibitors either undergo chemical reactions with the enzymes and thereby altered the configuration of the enzymes or form bond with enzymes substrate complex to form an inactive compound. They normally stop the working of enzymes and effect cannot be overcome by increasing the concentration of the substrate.

E I EI

E + S + I ESI

Examples are effects of poisons, heavy meals (Hg, Au, Ag), cyanide and carbon monoxide on the enzyme system.

Commercial uses of enzymes

a. Papain obtains from plants e.g. pawpaw leaves protease is sold as meat tenderizer (Adolf's). It beaks down protein into peptones and makes the meat soft

b. Protein digesting subtilisin (from Bacillus subtilis) is incorporated into presoak laundry agents and detergents for cleaning purposes. It is effective in removing protein containing stains (chocolate or coffee) from clothes, carpets etc.

c. Synthetic amylase is used in beer industry to break down starch substances into maltose

d. Synthetic cellulose is used in the textile industry to break down clothes into pieces or yarns

Plant Hormones

Also called phytohormones and they are substances that regulate plant growth and development. Phytohormones are divided into groups, namely:

i. Growth promoters

ii. Growth inhibitors

Growth promoters are further divided into auxins, gibberellins, cytokinins and ethylene while growth inhibitors consists of abscisic acid, phenolics e.g caffeine, glycosides, alkaloids and actinomycin D.

Auxins

These are substances which are chemically and/or biologically similar to indole-3-acetic acid (IAA). Auxins consists of natural auxins and synthetic auxins. The most important natural auxins is IAA while other example are indoleethanol(Iethanol), indoacetonitrile(IAN), and indolepyruvic acid (IPA). Site of production of natural auxins is the stem apical tip while site of activity is the cell. Synthetic auxins are laboratory-made auxins and examples are 2, 4-dichlorophenoxyacetic acid (2,4-D).

Indole-3-butyic acid (IBA)

Naphthalene acetic acid (NAA)

PHYSIOLOGICAL EFFECTS OF AUXINS ON PLANTS

(a) Cell enlargement

(b) Rooting of twig

(c) Permeability of cell membrane

(d) Maturation of fruits

(e) Inhibition of abscission and fruit fall

(f) Apical dominance

(g) Geotropism and phototropism

(h) Parthenocarpy

(i) Herbicides (synthetic ones only)

Transport of auxin is through the phloem

Gibberellins

More than 50 gibberellin types have been isolated. They are numbered as

GA_1 GA_{34}

GA_1 $C_{19}H_{22}O_6$ = CA2 = $C_{19}H_{26}O_6$

GA3=$C_{19}H_{22}$ O6 GA4 = C19H24O5

GA5 = C19H22O5, GA6 = C19H24O4

Physiological effects of gibberellis on plants

a. Cell elongation

b. Parthenocarpy

c. Promotion of cambial activity

d. Induce new ma and protein synthesis

e. Inhibiting leaf senescence

f. Overcoming of genetic dwarfism

g. Induction of flowering

h. Mobilization of stored carbohydrates during germination

i. Breaking of dormancy of dormant seeds and buds

Cytokinins

These are compounds with kinetin like action. They are degradation products of DNA and RNA coconut milk contains cytokinins. Examples ribosylzeatin (from maize), 6-methylaminopurine (from microbes RNA), kinetin (from maize) and 6-benzyl aminopuyrine (from microbes RNA). Cytokinins are synthesized in the roots and transported through the xylem.

Physiological effects of cytokinins on plants

(a) Cell divisions with auxin e.g. in tissues culture

(b) Cell enlargement with auxin or gibberelin

(c) Root initiation and growth

(d) Breaking of dormancy of dormant seeds and buds

(e) Inhibition of leaf senescence

(f) Stimulation of water loss by transpiration

(g) Promotion of bud formation in leaf cuttings

Abscisic acid (ABA)

This is a growth inhibitor which has opposite effects to growth promoters e.g. promotion of dormancy, promotion of senescences and abscission. Other inhibitors are phenolics, glycosides, alkaloids.

Transport of ABA is though the phloem

Ethylene (C2H4)

This is a gas at room temperature and it is found in plants as a gas.

Physiological effects of ethylene on plants

(a) Frit ripening

(b) Inhibition of geotropism otiolated pea stems in ethylene are not affected by gravity

(c) Promoter of dormant bud and seed germination

(d) Inhibition of auxin transport

(e) Promotion of enzyme synthesis e.g. amylase

(f) Promoter of leaf senescence and abscission

Transport of ethylene is through the intercellular spaces.

Economic importance of plant hormones

(a) Synthetic auxons are used as herbicides

(b) Control of dwarfism in plants using gibberellins

(c) Formation of fruits without fertilization from flowers (parthenocarpy) IAA

(d) Flowr initiation gibberellins

(e) Breaking of dormancy of dormant seeds and buds gibberellins and kinetin

(f) Fruit ripening ethylene

(g) As antitranspirants ABA

(h) Acceleration of leaf and fruit fall ABA and ethylene

(i) Inhibition of fruit ripening and senescence auxins, gibberellins, cytokinins

Chemical structures of some plant hormones:
(Diagram)

ENDOCRINE SYSTEMS

Introduction (Hormones in Human being)

Two communication systems (by which coordination of activities is brought about) exists in most animals one of these is the system. It consists of specialized cells, neurons, which transmit electrical impulses from one part of the body to another. The other is the endocrine system. This system achieve control of body functions through chemical substances i.e. hormones, which are transported throughout the body is the blood. There is a close connection between the activities of these two systems.

Chemical co-ordination in animals, like chemical co-ordination in plants, involves (1) the release of chemicals from cells into the extra cellular fluid (ECF) (2) the transport of these substances (3) the effect of the chemical substances on the activities of other cells.

Various groups of special clusters of cells those sole functions is the production and release of the various chemical co-ordinations (Hormones) exist in the different part of the human body. These clusters of cells are the endocrine glands. They are often referred to as ductless glands because their secretions i.e. the hormones pass directly into the blood that drains the gland. The hormones are then varied to all the other cells of the body. More often hormones exert their effect only on certain body structures referred to as "Target organs".

THYROID GLAND

The thyroid gland is a double-lobed structure located in the neck. It has a rich supply of blood. The thyroid gland releases the iodine containing amino acids, thyroxin. The control of this hormone is on the rate of body metabolism. When thyroxin is administered, the rate of oxygen consumption increases, the amount of heat produced is also increased.

Several human diseases are associated with the improper functioning of the thyroid gland. Some are associated with excessive production of thyroxin i.e. hyperthyroidism and some with insufficient production of hormone i.e. hypothyroidism.

Hypotheroidism before maturity results in cretinism. The victim of cretinism fails to attain either normal physical or mental development. Cretinism is prevalent in areas where insufficient iodine is present in diet. Symptoms of creatinism can be prevented by early and regular administration of thyroxin.

Hypothyroidism in adults causes myxedeme. The symptom of this disease is low metabolic rates, overweight and a coarsening of the features. It is also prevalent in iodine deficient areas.

Sample Goiter: is a disease associated with deficiency of iodine. A goiter is a swelling of neck caused by swelling of the thyroid gland. This occurs when the thyroid gland is stimulated by TSH (Throid stimulating hormone from the pituitary gland) to produce thyroxin under a condition of insufficient iodine.

PARATHYROID GLANDS: These are four tiny structures imbedded in the near surface of the thyroid glands. They secrete PTH parathyroid hormone. This hormone promotes (a) the release of Ca^{++} from the bones (b) the absorption of Ca^{++} from the food in the intestine (c) reabsorption of Ca^{++} in the tubules of the kidney.

Parathyroid hormone inhibits the reabsorption of PO_4 in the kidney tubules and thus helps rid the body of excess PO_4 produced.

A hormone which also controls the excess of Ca^{++} in the blood is calcitonim which is produced in the thyroid gland. This prevents the overshooting of Ca^{++} level in the body.

THE SKIN

When ultraviolet radiation strikes the skin, it trigger the conversion of dehydrocholesterol into calciferol (Vitamin D). in its chemical structure and mode of action, calciferol meets all criteria of a hormone. After synthesis in the skin, it is released into the blood where it is carried into the liver where it is modified and then into the kidney where it undergoes second modification into 1, 2-dihydroxy vitamin D. This enhances the absorption of Ca^{++} from the intestinal contents. Thus this hormone teams up with PTH (Parathyroid hormone) and calcitonin in the regulation of calcium metabolism. Lack of calciferol prevent normal deposition of calcium in bone. In child hood lack of calciferol leads to deformed bones characteristics of rickets. In adult inadequate amounts of calciferol lead to a weakening of the bones, a condition known as osteomalacia.

STOMACH AND DUODENUM Gastrin a polypeptide is a hormone secreted into the blood by cells in the stomach wall. This stimulates the production of HCL by the parietal cells of the stomach secretin and Pancreozymin is secreted by cells in the stomach. These hormones when in the pancrease, stimulate the secretion of the various component of the pancreatic digestive juice and when in the liver and gall bladder they stimulate secretion and release of bile.

ISLETS OF LANGERHAQNS

These are specialized clusters of cells in the pancrease. They secrete the hormone insulin, a protein. Insulin acts to lower the level of glucose in the blood stream. One of the ways in which this is achieved is through the speeding up of the conversion of glucose into glycogen and fats in the liver.

Insulin also stimulates the synthesis of proteins, including enzymes that participate in carbohydrates metabolism.

Insufficient production of insulin results in the disease diabetes mellitus. Victim of this disease are unable to cope with excess glucose in the blood, through conversion of glucose to glycogen. Moreover glycogen, body fat and protein are converted to glucose. Victims also urinate copiously and frequently. The second pancreatic hormone is glucogen which also stimulates the conversion of liver glycogen into glucose. Glucogen may act to present insulin from lowering the blood sugar level excessively. Glucagen thus play a role in establishing a constant level of glucose in the blood.

PITUITARY GLAND

The pituitary gland is a pea-sized structured located at the base of the brain. In adult vertebrate it consists of the interior and posterior lobes, the intermediate lobe being vestigial.

The pituitary gland play a vital role in the chemical coordination of the body. It is often called the "master" gland because many of its secretion control the activity of other endocrine glands.

(a) Hormones of the interior lobe

(i)Human Growth Hormone (HGH): This hormone is a protein. It promotes growth of the skeleton and the body as a whole. This is done by stimulating the liver to produce Somatomedin which promotes the growth of muscle, cartilage, bone and other connecting tissues. HCH is normally active in this respect only during the years of childhood and adolescence. Hyposecretion i.e. undersecretion of HGH in the child results in stunted growth or dwarfism. A hyposecretion of HGH during this same period results in giantism.

(ii) Prolactin: This is a protein hormone secreted by the females during and after pregnancy. It stimulates the development of the mammary glands during pregnancy and following child birth, and the production of milk by them.

iii. Thyroid-stimulating hormone (TSH): This hormone stimulates the thyroid gland to secrete thyroxin. The secretion of TSH is in turn depressed by thyroxin, thus there exist a homeostatic control mechanism over the level of thyroxin in the blood.

iv. Adrenocorticotropic Hormone (ACTH): This is a protein hormone, and it stimulate the cortex and the adrenal gland to release some of its hormone into the blood.

v. Follicle stimulating Hormone (FSH): This acts upon the gonads or sex organs. In females FSH promotes development follicles within the ovary. In conjunction with another pituitary hormone luteinizing hormone (IH), it stimulates the secretion of estrogen by the follicle and the ripening of the egg within it. FSH in human male stimulates the development of seminiferous tubules and the production of sperm.

vi. Lentinizing hormone (LH): This hormone triggers the transformation of the cells of the follicles (after the eggs have been released) into corpus luteum. This LH also stimulates the corpus luteum to secrete its hormone progesterone. LH in males stimulates the release of male sex hormones (androgens) (by the interstitial cells of the testes) into the blood stream.

vii. Melanocyte stimulating hormone (MSH): This is a protein hormone whose target cells are the melanocytes, cells which contain the black pigment melanin. Increase in MSH cause some darkening of human body during pregnancy.

(B) Hormone of the posterior lobe

(i) Oxytocin: This is protein hormone which stimulates contraction of smooth muscles, especially those of the uterus. Infection of oxytocin hastens delivery of the baby and also hasten the return of the uterus to its normal size.

(ii) Antidiuretic hormone (ADH) or Vasopressin: This is also a protein hormone. It causes the muscular walls of the arterioles to contract in human thus causing increase in blood pressure. ADH also stimulates reabsorption of water from the tubules of the kidney insufficient production of ADH causes enormous loss of water through the kidneys.

This disease is known as diabetes insipidus. Copius urine produced by hyposecretion of ADH is very watery and has no marked taste.

HYPOTHALAMUS: This is a region of the brain of the hypothalamus is connected with the pituitary gland. There is a direct nerve connection between the hypothalamus and the posterior lobe of the pituitary gland. The release of hormone by the pituitary gland is partly influenced by the nervous activity in the hypothalamus. Three of the hormones secreted by the hypothalamus are: (i) Thyrotropin releasing hormone (TRH). This hormone stimulates the anterior lobe to secrete TSH (Thyroxin, stimulating hormone) (ii) gonadotropin releasing hormone (GNRH) stimulates the anterior lobe to secrete LH (luteinizing hormone) and FSH. Hence it can be called LH-releasing hormone (LH RH) (iii) Somatotropin-release-inhibiting-factor SRIF or stomatostatin: This polypeptide inhibits the secretion of growth hormone. It also suppresses the secretion of TSH, prolactin, insulin and glucagon.

THE ADRENAL GLANDS

These are two small structures situated one at the top of each kidney. Each consist of two parts the exterior portion is the adrenal cortex while he interior portion of the gland is adrenal medulla.

(A) Hormones of the Adrenal medulla

Apart from being an endocrine gland and adrenal medulla is also considered to be a part of the nervous system. Its secretory cells seem to be modified nerve cells. Two hormones secreted by adrenal medulla are adrenaline and noradrenaline.

(i)Adrenalin

Large quantities of this hormone are released into the blood stream when the organism is suddenly subjected to stress such as anger, fright or infury. Once in the body, adrenaline promotes a wide variety of responses for example the rate and strength of heart beat is increased, thus increasing the blood pressure. A larger part of the blood supply of the skin and viscera is shunted to the skeletal muscles, coronary arteries, liver and brain. The level of blood sugar rises and metabolic rate increases. The bronchi dilates, permitting easier passage of air to and from the lungs. The pupils of the eye dilate and there is tendency for the body hair to stand.

(ii) Noradrenaline also causes an increase in blood pressure by stimulating the contraction of the arterioles. Almost all the body responses to these two hormones can be seen to prepare the body for violent physical action.

(B) Hormones of the adrenal cortex:

Most of the hormones of this gland are steroids (lipids). These hormones fall into the two major groups viz: glucorticoids and mineralocorticoids.

(i)Glucoritcoids: The most important members of this group are the cortisol and corticosterone. These hormones promote the conversion of fat and protein into intermediary metabolites that are ultimately converted into glucose thus causing the level of blood glucose to rise. One of the chief target organs in this response is the liver. The glucorticoids also act to suppress inflammation in the body. They are needed to maintain the body during period of stress after the fruit brief adrenaline stimulated response when the levels of glucose and salt in the blood drop sharply.

(ii) Mineralocorticoids: The chief cuntion of these hormones of which Aldosterone is the most important in humans, is to promote the reabsorption of Na^+ and Ci^- ions in the tubules of the kidneys. Retention of these ions in the blood keeps its osmotic pressure high. This in turn, assures normal blood pressure.

THE GONADS

Both the male and female gonads possess endocrine activities in addition to their prime function of producing the sex cells.

(a) The Testes: The interstitial cells of the testes are the endocrine tissue. When stimulated by the LH hormone from the pituitary gland, these cells release androgens (e.g. testosterone) into the blood stream. These responses start at beginning of adolescence. Testosterone triggers the development of the so called secondary sexual characteristics found in adult male.

(b) The Ovaries

The ripening follicle in the ovary not only contains a ripening egg but also act as an endocrine gland. The necessary cells of the follicle liberate several steroid hormones called oestrogens. They are stimulated to do so by the combined influence of FSH and LH from the anterior lobe of the pituitary gland.

The oestrogens in female body, promote the development early in adolescence of the secondary sexual characteristics. They also participate in the monthly preparation of the body for possible pregnancy. This includes the preparation of endomentrium (inner living in the uterus).

The corpus luteum is also an endocrine gland stimulated by LH. It secretes progesterone into the blood stream. This hormone continues the preparation of the uterus for pregnancy and inhibits the development of new follicle. As the time of birth approaches in the mother, secretion of progesterone declines and is replaced by another hormone relaxin. This hormone causes the ligaments between the pelvic bones to loosen which provides a more flexible passage way for the baby during birth.

The secretion of estrogens is stimulated by PSH and LH, while the secretion of progesterone is stimulated by LH alone.

THE PLACENTA

After pregnancy is established, the placenta takes on the secondary function of serving as endocrine gland. It secretes strogens, progesterone and hormone called human chorionic gonadotropin (HCG) quite similar to the gonad stimulating hormone of the anterior lobe of the pituitary gland. These hormones supplement those produced by the corpus luteum and the pituitary gland.

PINEAL GLAND

The pineal gland is a small, pea-sized structure attached to the brain far above the cerebellum. It produces hormone called melatonin. The role of this in human is not certain.

THYMUS GLAND

The thymus gland consists of the lobes of tissue similar to that found in lymph modes. It is located high in the chest cavity just under the breast bone. It is large during childhood but then shrinks after the start of adolescence.

There is good evidence that the thymus in the infant animal plays a major role in setting up the lymphocyte producing machinery of the lymph nodes, thus providing the basis for the development of antibodies. This seems to involved among other things production of one or more hormones called (thymosins). Once the job is completed the thymus is ordinarily no longer needed.

KIDNEY: Apart from other functions the kidney secretes erythropoietin into the blood stream especially in response to anaemia. Erythropoietin acts on the bone marrow to increase the production of red blood cells.

Pituitary (below the brain) secretes many different hormones	Trophic hormones: stimulate the following endocrine glands to release their hormones 1. Thyroid – thyrotropin 2. Adrenal – corticotrophin 3. Ovaries and testes gonadotropins Growth hormone: Somatotropin promotes growth of whole body neuro secretions (1) ADH, antidiuretic hormone vasopressin kidney water reabsorption (2) Oxytocin – uterus contraction	Disorders or normal gland function Excess: gigantism Deficiency: dwarfism Disorders of normal function e.g. water diabetes

	prolactin – milk secretion	
Thyroid	Throxine (a) Controls body metabolism, energy release in mitochondrion (b) Influence growth (tadpole metamorphosis)	Deficiency: cretinism in children Deficiency in adults, slowing down metabolism sluggishness Excess: eyeballs protrude metabolism, increased restlessness
Adrenals (close to kidneys)	Medulla hormones: mainly adrenaline 1. Affects blood circulation by increased heartbeat, blood flow vasodilation prepares body for fight or flight 2. Slows down kidney function 3. Increases blood sugar conversion from glycogen Cortex hormones: Hydrocortisone in metabolism of lipid, protein and carbohydrates	Deficiency: blood sugar disorder, combats stress
Pancreas	Mainly insulin: controls blood sugar, converts glucose to glycogen. Glucagon converts glycogen to glucose	Deficiency: sugar diabetes increase in blood sugar level. Excess nerve cell starvation and coma
Gonads (male and female reproductive organs)	Oestrogen (female ovary) secondary sexual features, pubic hair mammary gland and menstrual cycle. Progesterone = change in uterus after ovulation and testosterone in pregnancy (male testes) secondary sexual features, voice change, pubic hair, facial hair	General personality and sexual changes, sterility and abortion
Adrenal cortex	Sex hormone producing body changes as for gonads	Excess sexual desire changes
Digestive tract 1. Stomach 2. Intestine wall	Gastrin: stimulates gastric juice secretion Secretion/stimulates pancreatic juice flow	

Endocrine systems in Human being (diagram)